S. S. Day
from
Honl Wm H. Russell

Drawn by Arthur Schott. Pl. 47. Engraved by James D. Smillie.

MILITARY PLAZA — SAN ANTONIO, TEXAS.

34th Congress, 1st Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. No. 135.

REPORT

ON THE

UNITED STATES AND MEXICAN BOUNDARY SURVEY,

MADE UNDER

THE DIRECTION OF THE SECRETARY OF THE INTERIOR,

BY

WILLIAM H. EMORY.

MAJOR FIRST CAVALRY AND UNITED STATES COMMISSIONER.

VOLUME I.

WASHINGTON:
CORNELIUS WENDELL, PRINTER.
1857.

IN THE HOUSE OF REPRESENTATIVES.

AUGUST 15, 1856.

Resolved, That there be printed, for distribution by the members of this House, ten thousand extra copies of Major Emory's Report on the Survey of the Boundary between the United States and Mexico.

Attest: WM. CULLOM, *Clerk.*

PART I.

MESSAGE

FROM

THE PRESIDENT OF THE UNITED STATES,

COMMUNICATING

A report of Major Emory, United States Commissioner, on the survey of the boundary between the United States and Mexico, accompanied by a letter from the Secretary of the Interior.

August 7, 1856.—Read, and ordered to lie on the table. Resolution to refer to Committee on Printing agreed to.

August 15, 1856.—Ordered to be printed in quarto form, and that 5,000 additional copies of the report proper, with the maps, and 2,000 copies of the appendix, be printed—250 copies of the former, and twenty-five copies of the latter, be furnished the said commissioner.

Washington, *August* 1, 1856.

To the Senate and House of Representatives of the United States:

I communicate to Congress, herewith, the report of Major W. H. Emory, United States Commissioner, on the survey of the boundary between the United States and the republic of Mexico, referred to in the accompanying letter of this date from the Secretary of the Interior.

FRANKLIN PIERCE.

Department of the Interior,
Washington, August 1, 1856.

Sir: I have the honor to submit to you, herewith, to be laid before Congress, a report of Major W. H. Emory, United States Commissioner, on the survey of the boundary between the United States and the republic of Mexico.

I am, sir, very respectfully, your obedient servant,

R. McCLELLAND.
Secretary.

The President of the United States.

OFFICE UNITED STATES BOUNDARY COMMISSION,
Washington, July 29, 1856.

SIR: I have the honor to send herewith my report on the boundary between the United States and Mexico, together with proofs of such maps and illustrations as have been completed, numbered from 1 to 63. The plates and blocks from which these proofs are struck are held by me subject to your order, or that of Congress.

The general map cannot be completed until next winter, and the map of the new Territory is not quite completed, but when finished, no delay will ensue in the publication. By consultation with the printer, I find these maps will be done quite as soon as the printing of the report, should it be concluded to print that report.

Besides the volume now sent in, there will be an appendix, containing reports upon the botany and natural history of the country adjacent to the boundary, with from two to three hundred illustrations, many of which are already engraved and the plates deposited in this office. These reports are in the hands of Drs. Torrey, Engelmann, and Professor Baird, and other savans of the country. They promise to have them all finished in the course of the year. These reports not being of the same general interest, I concluded it was proper not to delay sending in the general report until their completion.

Should it be deemed proper to publish the general report and a limited number of copies of the appendix, I beg to call attention to my letter to you of April 23, 1856, by which it will be seen there is a large surplus of funds which may be made available for the purpose, and which has been saved from the appropriations made by Congress for the prosecution of the work. That surplus is at present more than $100,000.

I have the honor to be, your obedient servant,

W. H. EMORY,
United States Commissioner.

Hon. ROBERT McCLELLAND,
Secretary of the Interior.

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* The peak represented in the wood cut as "Gomez Peak," is incorrectly named in the report—it is properly called "Mitre Peak."

ERRATA.

Page 4, line 37, for "steppes" read steps.

Page 24, line 17, for "Chas. Weiss" read John E. Weiss.

Page 24. The name C. B. R. Kennerly, surgeon, omitted, should come after J. E. Weiss.

Page 41, line 17, for "4,000" read 5,000.

Page 66, line 3, for "Los Adjuntas" read Las Adjuntas.

Page 70, line 21, for "Zocate" read Zoqueté.

Page 85, line 1, for "Beyonp" read Beyond.

Page 115, line 34, for "laid" read lay.

Page 120, line 19, for "present" read presents.

Page 121, line 30, for "Fonquicra" read Fouquiera.

Page 127, line 29, for "fluviatic" read fluviatile.

Page 128, line 41, for "Yumas" read Yuma.

Page 134, line 31, for "Pelatado" read Palotal.

Page 134, line 37, for "Samalurca" read Samalayurca.

Page 125, line 4, for "1,727.32" read 1,730.50.

Page 125, line 6, for "1,695.22" read 1,698.40.

Page 113, line 39, for "Manual" read Manuel.

Page 68, line 12, for "Islitas" read Islétas.

Page 123, line 17, for "Babuquivari" read Baboquivari.

Page 131. The distances from New San Diego to Fort Yuma were measured by Major N. W. Brown, paymaster U. S. A. Those from the Pacific ocean to the Gulf of Mexico, not otherwise designated, were measured under the direction of Lieut. N. Michler.

PREFATORY REMARKS.

The instructions given to me August 15, 1854, by the Hon. Robert McClelland, Secretary of the Interior, direct that, "in all cases where they do not conflict with the stipulations of the treaty, or the specific directions contained in these instructions, you will be guided by the instructions issued by the Department of State, and those of this department, to the Commissioner, for running and marking the boundary line under the treaty of Guadalupe Hidalgo."

The instructions referred to, given to one of my predecessors, and not repealed, directed an examination of the country contiguous to the line to ascertain its practicability for a railway route to the Pacific; and also directed information to be collected in reference to the agricultural and mineral resources, and such other subjects as would give a correct knowledge of the physical character of the country and its present occupants.

A compliance with these instructions has necessarily extended this report very much beyond the limits of the record necessary to show the official acts of the joint commission.

Fifteen thousand extra copies of this report have been ordered by Congress. It consists of two volumes, divided into four parts. The first part comprises the personal narrative; general description of the country; journal of the joint commission; the astronomical work; barometrical levels; meteorological record, and magnetic observations. The second part consists of the geological researches, with annotations, and a review of the whole by Professor James Hall. The third part comprises the general botanical features of the country, by Dr. John Torrey, described from memoirs of the assistants, and from the plants themselves, and a separte description of the cactaceæ, by Dr. George Engelmann, of St. Louis. The fourth part embraces the natural history of the country, by Spencer F. Baird, based upon the notes and memoirs by the assistants, and upon the specimens themselves.

The first two parts, forming volume I, are now presented to the government; the third and fourth parts, forming volume II, are delayed in consequence of the difficulty of getting the illustrations engraved.

Accompanying the first volume are five maps: first, a general map on a scale of $\frac{1}{6000000}$, and maps numbered from 1 to 4, on a scale of $\frac{1}{60000}$, showing the boundary line and topography of the country contiguous, as far as information has been obtained from actual survey or reconnoissance. If these maps were placed in the hands of department commanders, with directions to fill up the intervals not covered by actual survey, from the best information within their reach, which, from the numerous expeditions sent out under intelligent officers of the army, is very great, the government would be in possession of delineations of our whole southern frontier, more authentic in character than the maps of many of the old States.

I have confined myself in all these maps, except the general map, to actual information, derived from instrumental survey, and in doing so, have sacrificed considerable general interest which might have been given them had I incorporated all the loose information which exists

For the performance of this portion of the treaty, each of the two governments shall nominate one commissioner, to the end that, by common consent, the two thus nominated, having met in the city of Paso del Norte, three months after the exchange of the ratifications of this treaty, may proceed to survey and mark out upon the land the dividing line stipulated by this article, where it shall not have already been surveyed and established by the mixed commission, according to the treaty of Guadalupe, keeping a journal and making proper plans of their operations. For this purpose, if they should judge it necessary, the contracting parties shall be at liberty each to unite to its respective commissioner, scientific or other assistants, such as astronomers and surveyors, whose concurrence shall not be considered necessary for the settlement and ratification of a true line of division between the two republics; that line shall be alone established upon which the commissioners may fix, their consent in this particular being considered decisive and an integral part of this treaty, without necessity of ulterior ratification or approval, and without room for interpretation of any kind by either of the parties contracting.

The dividing line thus established shall, in all time, be faithfully respected by the two governments, without any variation therein, unless of the express and free consent of the two, given in conformity to the principles of the law of nations, and in accordance with the constitution of each country, respectively.

In consequence, the stipulation in the 5th article of the treaty of Guadalupe upon the boundary line therein described is no longer of any force, wherein it may conflict with that here established, the said line being considered annulled and abolished wherever it may not coincide with the present, and in the same manner remaining in full force where in accordance with the same.

ARTICLE II.

The government of Mexico hereby releases the United States from all liability on account of the obligations contained in the eleventh article of the treaty of Guadalupe Hidalgo; and the said article and the thirty-third article of the treaty of amity, commerce, and navigation between the United States of America and the United Mexican States concluded at Mexico, on the fifth day of April, 1831, are hereby abrogated.

FRANKLIN PIERCE, *President of the United States of America:*

To all who shall see these presents, greeting: Know ye, that, reposing special trust and confidence in the integrity, ability, and diligence of William H. Emory, of the District of Columbia, I do appoint him to be commissioner, on the part of the United States of America, to run the boundary line between the United States and the Mexican republic according to the treaty between the two nations entered into the 30th day of December, 1853, and do authorize and empower him to execute and fulfil the duties of that office according to law; and to have and to hold the said office, with all the powers, privileges, and emoluments thereunto legally appertaining unto him, the said William H. Emory, during the pleasure of the President of the United States for the time being.

In testimony whereof, I have caused these letters to be made patent, and the seal of the Department of the Interior of the United States to be hereunto affixed. Given under my hand, at the city of Washington, the fourth day of August, in the year of our Lord one thousand eight hundred and fifty-four, and of the independence of the United States of America the seventy-ninth.

[SEAL.]

FRANKLIN PIERCE.

By the President:

ROBERT McCLELLAND,
Secretary of the Interior.


MAP OF THE
UNITED STATES AND THEIR TERRITORIES
BETWEEN THE
MISSISSIPPI AND THE PACIFIC OCEAN
AND PART OF MEXICO
COMPILED FROM SURVEYS MADE UNDER THE ORDER OF
W. H. EMORY
Major 1st Cavalry U. S. Commissioner
And from the Maps of the Pacific Rail Road, General Land Office, and the Coast Survey.
Projected and drawn under the supervision of Lt. N. MICHLER, Topl. Engr.
BY THOMAS JEKYLL, C.E.
BRITISH POSSESSIONS
WASHINGTON
OREGON
NEBRASKA
MINNESOTA
WISCONSIN
MICHIGAN
IOWA
ILLINOIS
UTAH
KANSAS
MISSOURI
KENTUCKY
TENNESSEE
ARKANSAS
NEW MEXICO
TEXAS
LOUISIANA
CALIFORNIA
PACIFIC OCEAN
GULF OF MEXICO
LAKE SUPERIOR

CHAPTER I.

PERSONAL ACCOUNT.

ORGANIZATION OF THE COMMISSION FOR RUNNING THE BOUNDARY LINE BETWEEN THE UNITED STATES AND THE REPUBLIC OF MEXICO, UNDER THE TREATY OF AUGUST, 1848.—CHANGES IN THE HEAD OF THE COMMISSION.—GOLD MANIA IN CALIFORNIA.—FAILURE OF THE GOVERNMENT TO KEEP ITS ENGAGEMENTS.—MISAPPLICATION OF THE PUBLIC MONEY.—GENERAL MISMANAGEMENT OF THE AFFAIRS OF THE COMMISSION.—FINAL REORGANIZATION.—CORRECTION OF STATEMENTS IN MR. BARTLETT'S NARRATIVE.

The narrative of the connexion which different individuals have had with the Boundary Commission would no doubt be instructive, but the commission organized under the treaty of Guadalupe Hidalgo was changed so frequently, and the controversies between different members of the commission were so acrimonious, as to make the task both complicated and unpleasant, and the execution of it might, perhaps, be attended with injustice.

I will, therefore, confine myself to such accounts as will enable the government, should occasion require it, to trace the history of the work, or any particular portion of it, and to the correction of some erroneous impressions which have gone abroad, not under authority of the government, but of books published as a private venture.

There have been two boundaries agreed upon with Mexico—that provided for in the treaty of Guadalupe Hidalgo, August, 1848, and that which now exists as the boundary, agreed upon in the city of Mexico, December 30, 1853, and usually known as the Gadsden treaty.

The treaty under which the first commission was organized required the appointment of a commissioner and surveyor, to run and mark the boundary from the Pacific to the Atlantic, a distance following the sinuosities of the boundary of several thousand miles, extending over a portion of the Continent but little known, and diversified with much variety of climate and topography, and infested throughout its whole extent with formidable and hostile bands of Indians.

I traversed a considerable portion of the line, in the campaign of 1846 and 1847, and made a reconnoissance of the country adjacent. The information obtained formed the basis of Mr. Buchanan's specific instructions to our minister in Mexico, in reference to the boundary, which instructions, unfortunately for the country, were not carried out.

It was, no doubt, from my supposed knowledge of the country that President Polk tendered me the office of commissioner, but attached the condition that I should resign from the army. This I respectfully declined. Colonel Weller was then appointed commissioner, and I was attached to the commission as chief astronomer and commander of the escort of United States troops, which was to accompany it.

The commission was organized on a moderate plan, and proceeded, according to the terms of the treaty, to commence at a point south of San Diego, on the Pacific side. The only way to get there was by Cape Horn or by the Isthmus of Panama. Most of the commission took the latter route, and reached Panama in March, 1849, expecting to meet one of the line of mail

steamers just established by the government. In this we were disappointed, and were kept in Panama, at great expense, until the middle of May.

Soon after the organization of the commission in Washington, and on the eve of departure, the news came of the discovery of fields of gold in California. This report set all "the wide awake" and unemployed men in the country in motion towards the new Eldorado, and it was with the greatest difficulty that passage to Chagres could be procured in the meanest craft. Every steamer and sailing vessel, without regard to sea-going qualities, that could be drawn from the regular channels of commerce, were put in requisition, and it was with considerable trouble that I procured a passage in the steamer Northerner, which sailed from New York.

Simultaneously with our arrival on the Isthmus, there was a precipitation upon it of all the odds and ends of the inhabitants of the Atlantic coast of North America and Europe. The state of Panama, with its mongrel race of Indians, negroes and Spaniards, with their intellects obfuscated by bigotry, and their bodies enervated by a tropical climate, was wholly unequal to the task of receiving and entertaining, in an orderly manner, such an influx of strangers. Fortunately, the mass of them was of the self-governing race of the whites of North America, and when disorder and confusion seemed inevitable, propriety resumed the sway, and a germ of civil liberty and self-government was planted for the first time in that mis-called republic, the fruits of which are now beginning to be made apparent in the new code of laws, and the extended and liberal views of some of her citizens; among whom stands conspicuously Señor Arosemena, to whose good offices we were indebted for a roof over our heads during our long delay in Panama.

It was estimated that as many as four thousand people were collected in Panama, awaiting transportation to California. The price of passage-tickets in the expected steamers rose to an exorbitant sum. Each person seemed to think that there was a limited supply of gold, and that his hopes of getting any portion of it depended upon his early arrival in the field. Panama, at that time fallen into decay, and her name, in fact, stricken from the list of commercial cities, was out of the highway of ships. Boats, something in shape and awkwardness like the "dug-outs" of the Mississippi, in use among the natives to transport fruit from the neighboring island of Toboga, were the only description of vessels that could then be obtained. The largest of them did not exceed ten or fifteen tons in capacity. Yet many were put in requisition to navigate the ocean over a space of three thousand miles, extending along a rock-bound coast, swept for a considerable portion of the way by adverse north winds. Many of the bold adventurers were wrecked, and few, if any, reached their destination in their frail barks, but were obliged to put in at Acapulco and other ports along the coast.

Seeing that there was little probability of our obtaining passage to San Diego before the middle of May, I unpacked the instruments, and set them up for the double purpose of practising my assistants and making observations at Panama for latitude and longitude, magnetic dip and intensity, and other phenomena, the results of which will be found elsewhere. The result of these observations threw much light on the geographical position and the climate of those tropical regions; but as the observations upon which they were founded were published in the fifth volume of the proceedings of the American Academy of Arts and Sciences, at Boston, it has not been considered necessary to reproduce them in this work.

When we arrived, in March, the summer or dry season was not ended, and the country was very healthy; but towards the latter end of April the rainy season set in, and with it came fever and cholera. Rejecting the sanitary precautions of abstemiousness usually resorted to in such

cases, I employed a good cook, and purchased light wines, and, by a generous diet, myself and companions escaped all disease, although we were out every clear night observing—at a time when it was thought certain death to the foreigner to expose himself. I learned this agreeable preventive treatment in Vera Cruz, which I twice visited when the vomito was raging—the last time under aggravating circumstances. Being engaged in embarking my regiment, which was encamped two miles from the city, I was obliged to make frequent visits to the latter both night and day, exposed alternately to the scorching sun and the evening dews; and although frequently passing through infected districts since, it was not until the autumn of 1853 that I suffered from this disease. I attribute the attack at that time to the fact of being kept on board a ship, where, by an unexpectedly long voyage of eighteen days from Brazos Santiago to Pensacola, we were reduced to salt junk and whiskey. With the system suffering under this diet, I incautiously visited Mobile, where the epidemic was very violent. In all places where this malady has prevailed, it is undoubtedly the case that those addicted to the use of salt meats, brandy, whiskey, and the stronger wines, Madeira and Sherry, are the most likely to suffer. And we may not see any important changes in the health of the southern coast of the United States until its inhabitants shall conform to the habits of tropical nations—discard rich, unctuous food, and all alcoholic drinks, and substitute pilaus and the light wines which can be produced in the mountains of the Carolinas and Georgia, but more particularly in the champagne country of Texas.

It was not until after the middle of May that a steamer appeared in the harbor, which proved to be the "Panama," one of the line of United States Pacific mail steamers, upon which I had shipped from New York the heaviest of the astronomical instruments intended for the boundary survey, in charge of Captain Hardcastle, corps Topographical Engineers.

The "Panama" was built before the discovery of gold in California, when it was supposed but very little would be carried by her except the United States mails and the government officers passing to California and Oregon. Her tonnage was, I think, something under 1,000 tons; yet such was the irresistible press for passage to California, that when she weighed anchor to proceed on her voyage, no less than seven hundred souls, exclusive of her crew, were found to be on board. Every reasonable effort was made by Capt. Bailey and other officers of the ship to administer to our comforts, yet the voyage was of the most disagreeable and unsatisfactory character.

The treaty with Mexico required that we should be in San Diego on or before the 31st of May. We arrived there on the 1st of June, but finding the Mexican commissioner had not come, we were at once satisfied that no evil would result from the unavoidable delay. On reaching San Diego we found the escort of troops awaiting us. It was composed of company "A," 1st dragoons, commanded by Lieut. Coutts, and company "H," 2d infantry, commanded by Capt. Hayden.

San Diego appeared to me not to have changed since 1846–'47. The news of the discovery of gold in the northern part of California, produced less commotion in that quiet town than in New York or Panama. Fortunately for us, it did not feel the effect until the reaction came from the Atlantic side, some months after our arrival. Had it been otherwise, all attempts to keep together the enlisted men and laborers of the survey would have been idle, and the commission would have been disorganized before doing anything.

The Mexican commissioner arrived July 3, at San Diego, accompanied by one hundred and fifty troops. The joint commission was organized on the 6th, and on the 9th I established my

observatory at the Punta, and called it Camp Riley, after the general then commanding in California, to whom we were much indebted for affording many facilities in conducting the survey. The infantry company was encamped in the valley near me, and the dragoons were sent up the valley of the Tia Juana, to a point where the grazing was good, to get in condition for the hard service upon which they were soon to be employed.

The following distribution was made of that portion of the officers and employés of the boundary commission under my direction: Aided by James Nooney and George C. Gardner, I took the personal charge of the determination of the latitude and longitude of Camp Riley, and the triangulation by which that determination was to be carried to the initial point on the Pacific; no convenient place for wood and water, which was at the same time protected from winds and the drifting sands, being nearer to the initial point than Camp Riley.

Lieut. A. W. Whipple, corps Topographical Engineers, assisted by Messrs. Parry and Ingraham, were assigned to the charge of the party to determine the other extremity of the straight line forming the boundary at the junction of the Gila and Colorado. In addition to his duties as asssistant, Dr. Parry was charged with the geological and botanical investigations to illustrate the physical geography of the country.

Capt. E. L. F. Hardcastle, corps Topographical Engineers, assisted by Mr. George C. Gardner, and escorted by Lieut. Slaughter, with a detachment on foot, was placed in charge of the party to reconnoitre the country, gain a knowledge of the topography, and select elevated points by which the extremities of the line, or the two observatories in charge of Lieut. Whipple and myself, could be connected in longitude by flashes of gunpowder.

A party under the charge of the United States surveyor, assisted by Messrs. Whiting, Taylor, and Foster, were employed in surveying the shore-line of the head of the bay, for the purpose of showing on paper the initial point of the boundary on the coast of the Pacific, described in the treaty as being one marine league south of the port of San Diego.

The portion of the boundary which the commissioner designed to run first, consisted of a straight line from a point on the Pacific ocean, one marine league south of the port of San Diego, to the junction of the Gila and Colorado. The most obvious way of determining the direction of this line was to connect the two points by triangulation, and in this way ascertain their relative positions on the face of the earth, and compute the azimuth of the line joining them. But the character of the intervening country made it impossible to pursue this mode of operating, when the time and means at our disposal were considered. Triangulation is the most accurate, but the slowest and most expensive method of surveying, even in old settled countries, where the stations to be selected are easily accessible in wagons.

The peculiarities of this country presented obstacles almost insurmountable to such an operation. The whole distance, about 148 miles, may be divided into two nearly equal parts, differing in character, but both unfavorable to geodetic operations. The first, rising in steppes from the sea, devoid of water, and covered with spinous vegetation, attains in abrupt ascents the height of five or six thousand feet above the sea in the short distance of thirty miles. From this point, for about thirty miles more, the country is occupied by a succession of parallel ridges, striking the boundary nearly at right-angles, and separated by deep and sometimes impassable chasms. It then falls abruptly to near the level of the sea. The remainder of the line stretches across the desert of shifting sand at the head of the Gulf of California, destitute for the most part of both water and vegetation, rendering it impossible to mark the boundary in the usual manner on the ground.

At the various conferences of the joint commission, the mode of conducting the survey was discussed; and it was agreed to determine the line by astronomical methods, as the only mode by which we could do so correctly and within our means. Although not then a member of the joint commission, I was invited to their consultations; and my knowledge of the country, derived from a previous exploration, was brought into requisition.

I would here be doing injustice to Colonel Weller, the United States commissioner, and General Conde, the Mexican commissioner, if I did not place their conduct in contrast with what subsequently happened, by commending the just and enlarged views which guided their early conferences, and the intelligence and liberality with which all suggestions for the guidance of the scientific operations of the commission were received and adopted by those two gentlemen.

It will be seen by those conversant with geodetic matters, that the determination I had undertaken was of no ordinary kind, and required for its success the most accurate and elaborate observations, and a skilful application of those observations by analytic formulae, involving the figure of the earth and other elements, a perfect knowledge of which has not yet been attained, although researches upon the subject have occupied the minds of the great astronomers; and the last half century has seen their labors embodied, and our knowledge brought very near perfection, by the beautiful analysis of Bessel, and the successful application of that analysis by Professor A. D. Bache.

An error in the latitude or longitude of either extremity, of a few seconds, would produce a great departure of the line from the point it was intended to strike; the utmost precision was, therefore, necessary to be observed in all determinations connected with the line.

In this operation I looked for little or no aid from the Mexican commission, for although composed of well educated and scientific men, their instruments were radically defective. Our determinations, after being re-observed and re-computed by the Mexican commission, were received by them without correction; and the actual tracing of the line on the ground by the two parties, operating in different directions from the two extremities of the line, showed their correctness. When the parties met on the desert, they were found to be so nearly on the same line, that the difference might as properly be attributed to the inaccuracy of prolonging straight lines over such vast and almost impassable tracts, as to error in the original direction.

The elaborate observations and computations by which the result was arrived at, will be found in their proper place.

It was in the month of September, while engaged in this dreary and thankless work, that intelligence was received that Colonel Weller was removed, and Mr. J. C. Fremont was substituted. This official, although he accepted the appointment, afterwards declined it, and never joined the commission. At this time Colonel Weller was absent at the north, engaged in the fruitless task of raising funds. About the same time, intelligence reached our hitherto quiet and secluded camp, of the successful accumulation of wealth by many who had gone to the gold region without a dollar in their pockets. News came, too, that was afterwards confirmed, that Colonel Weller's drafts had been protested, his disbursements repudiated, and himself denounced as a defaulter; when, at that very time, as the settlement of his accounts afterwards showed, he was in advance to the government.

The wages of common laborers employed at the port of San Diego suddenly rose to $150 per month, and of carpenters to $10 per day. Subsistence of every kind rose in proportion; the

soldiers' rations from 20 cents to $1 50 per day. Our people had not been paid for some time, and we were without a dollar. This seemed more than poor human nature could bear, and one by one our force dropped off, until but four or five of the civil employés remained, and among them three persons in subordinate positions, whose fidelity, I think, deserves to be remembered—Francis Holley, Frank Stone, and my servant Robert, a slave.

I find no fault with any gentleman in civil life who left the commission at this time.

Had I not been an officer of the army in command of troops, and in charge of an important work co-operating with a foreign commission, I should have undoubtedly exercised the privilege of withdrawing. The government failed to comply with its obligations to pay the civil officers and employés their salaries, and even to supply them with the necessary subsistence. On the other hand, the field of gold was spread before them, and almost within their reach. I cannot say that any of the commission would have yielded to the temptation had those in authority been supplied with the means to pay them, or had they been invited to remain. As it was, I am not prepared to ay that one left the commission without receiving and deserving an honorable discharge, and not a single member ever deserted the commission. I was at this time in a position of extreme embarrassment. It was a critical period in the progress of the work. All the preliminary steps had been taken; the observations nearly completed at one end of the line, and the party designed for the mouth of the Gila ready to start; the commissioner absent; without a dollar in my pocket; the commission dishonored at home, and without credit in the field. In this dilemma I did not hesitate to take the responsibility of using the military power in my hands to keep the work from being abandoned.

I directed the quartermaster and commissary of the army attached to the escort to furnish supplies and transportation, and I engaged to give each soldier, with the assent of his captain, when not on military duty, two dollars for each day's work done in running the boundary.

This arrangement, which was cordially approved by the commissioner, and subsequently, on a change of administration, by the government, worked well in more ways than one. While it supplied me with the manual labor necessary to carry on the work, it prevented desertion from the escort, which, in other branches of the army in California, occurred to an alarming extent; in some cases entire guards going off with their arms. Throughout the whole campaign we had but three desertions, and when I was relieved from the command I was complimented in orders from the commanding general of California for the successful manner in which the troops had been held together.

The outrage inflicted on the commission by withholding funds, and attempting to place at its head persons under influences avowedly hostile, so far from shaking my interest in the great scientific work which I had commenced, only increased my determination to complete it. At the same time I felt it my duty to resent the indignity, by tendering my resignation, to take effect on the completion of the line I had commenced, which was the only one indeed in the boundary, as then agreed upon, involving any very great degree of scientific skill. I accordingly wrote to the honorable Secretary of State the following letter:

CAMP RILEY, *September* 15, 1849.

SIR: * * * * * * * * * * *

It is questionable in my mind whether the Department of State has followed up its intention, conveyed in the preliminary instructions of February 15. But if it has done so, and I am considered as occupying the position of chief astronomer and topographical engineer (of the boundary

commission,) I now desire, for reasons which, in my judgment, form an insurmountable obstacle to the proper performance of these duties, to be relieved from all duty on the commission.

I request the person may be designated to whom the instruments in my custody shall be turned over. They are at present distributed between Captain Hardcastle, Lieut. Whipple, Mr. A. B. Gray, and myself. In due season an account will be rendered of my astronomical determinations on this work, and the commission will be furnished with the result.

By the time of receiving my recall, I hope to have finished the determination of the astronomical line forming the boundary between the Pacific and the mouth of the Gila river, and it will be a convenient point for the transfer of the work to other hands.

* * * * * * * * * * *

I am, sir, very respectfully, your obedient servant,

W. H. EMORY.

In reply to this letter I received, almost simultaneously, the two following letters:

WASHINGTON, *November* 21, 1849.

SIR: Your letter of the 15th of September has been received. I learn from it with regret that you wish to be relieved from your duties as astronomer and topographical engineer, in connexion with the commission, on the part of the United States, for marking the boundary pursuant to the treaty of Guadalupe Hidalgo. Your claims and peculiar aptitude for that service were so generously acknowledged, that there was every reason to hope you might not be severed from the commission until the close of the business confided to it. Entertaining no doubt, however, that the reasons to which you allude are sound, and that the public will derive advantage from your employment in any other professional duty which may be assigned to you, your request is acceded to, and in a letter of this date I have requested the Secretary of War to designate your successor. In regard to the civil assistants to whom you refer, it is presumed that it would be best for them to remain, with a view to aid your successor in the discharge of his duties.

I am, sir, very respectfully, your obedient servant,

J. M. CLAYTON.

WASHINGTON, *November* 28, 1849.

SIR: The letter addressed to you by this department under date of 21st has been detained for the purpose of being sent by the officer whom the Secretary of War might appoint as your successor. It appears, however, from the communication of Mr. Crawford of this date, a copy of which is enclosed, that the order for your relief, which had been requested of him, would be so greatly inconvenient to the military service that he deems himself constrained to deny the request.

Under these circumstances, it is hoped that you will continue to discharge the duties of commander to the escort and chief astronomer to the commission, with the same fidelity and ability by which you have attained your high professional and personal character.

I am, sir, very respectfully, your obedient servant,

J. M. CLAYTON.

Major W. H. EMORY, *Astronomer, &c., &c.*

It might be supposed, after the receipt of these letters, that the desperate condition in which the affairs of the boundary commission had been left, by the neglect to supply it with funds,

had at last received the attention of the authorities at Washington, and that a brighter day was dawning on our work. Unfortunately for us, just after these letters were written, the work was transferred from the Department of State to the Department of the Interior, and these promising hopes were doomed to disappointment.

With the organization above described depending chiefly upon the military officers and escort attached to the commission, I completed the determination of the latitude and longitude of the two observatories near the extremities of the line, and proceeded to transfer, by triangulation, the determination of Camp Riley to the initial point on the Pacific. Although this was accomplished by a single triangle, the longest side of which was not five miles, such was the peculiarity of the atmosphere rendering objects near the coast indistinct, that I was nearly two months in completing this work satisfactorily. I had now lost nearly all my assistants, and the computation of the azimuth of the line and the tracing of the line on the face of the earth were done with no other aid than that of Captain Hardcastle and assistant Gardner and the infantry soldiers of the escort. Lieutenant Whipple, with the cavalry escort, was still at the junction of the Gila and Colorado, faithfully aided by the escort and assistants Parry and Ingraham.

In the mean time Colonel Weller had received official information that he was removed, and a successor, as before stated, was named who was to relieve him. His successor, however, never appeared, and things remained in a state of suspense until the receipt of the following letter:

DEPARTMENT OF THE INTERIOR,
Washington, January 8, 1850.

SIR: Mr. John B. Weller having been relieved from duty, as head of the commission to survey the boundary line between the United States and Mexico, and the direction of said commission having, therefore, fallen temporarily upon you, I have to request that the persons employed on the work may be reduced to the lowest number consistent with the proper though economical management of the business confided to you, by the discharge of all such as are not indispensable to the proper performance of the work, and whose services can therefore be dispensed with without detriment.

The number of surveyors ought not to exceed three; and in reducing the force you will have a view to the suggestions of Col. Abert to Lieut. Col. McClelland, a copy of which is enclosed.

I am, sir, very respectfully, your obedient servant,

T. EWING, *Secretary*.

Major W. H. EMORY, *San Diego, California*.

Upon the faith of these instructions, emanating, as they did, from the fountain-head of the authority of the government of the United States, I proceeded to reorganize the commission and make arrangements for the continuation of the survey of the line, and placed one efficient party in the field, under the charge of Capt. E. L. F. Hardcastle, and organized another to send by the most expeditious route to the Paso del Norte, on the Rio Grande, at which point it was agreed by the joint commission to meet in November of the same year, (1850.) A schedule of the reorganization and an application for funds, with an urgent letter showing our necessities, were sent and received by the Department of the Interior, and the following answer was returned:

DEPARTMENT OF THE INTERIOR,
Washington, April 10, 1850.

SIR: Your letter from San Diego, (without date,) enclosing papers marked 1 to 4, has been received.

The bill to supply deficiencies of appropriation for the present fiscal year, containing an appropriation for the boundary service, has passed the House and is now before the Senate, but will not probably be disposed of by that body in time to enable me to forward a remittance to you by the steamer which sails on the 13th instant. Funds will be sent to you, however, by the next departure from New York.

Your views as to the further prosecution of the work are generally approved, but you will receive more specific instructions by the next steamer; and you will in the mean time go on as you propose.

The monuments are in course of preparation, and will be sent as soon as practicable.

I am, sir, very respectfully, your obedient servant,

T. EWING, *Secretary.*

Major W. H. EMORY, *U. S. A., San Diego, California.*

Here is not only a distinct approval of my proceedings, but a promise that funds should be sent by the next steamer. Yet it will challenge belief when I state no money was sent, and the reorganization was practically repudiated by the appointment, for the second time, of a commissioner (Mr. J. R. Bartlett) to succeed Col. Weller, and new assistants were appointed, omitting all those appointed by me, under the authority and with the approbation of the Secretary himself.

To understand fully this extraordinary and inexplicable proceeding, and to give a comprehensive view of the gross injustice done not only to the individuals, but to the government, it must be borne in mind that we were co-operating with a foreign government in a great public undertaking, and that the few assistants who remained, faithfully performing their duties, did so at the sacrifice of going to the mines of California, where certain wealth awaited all who went at that time.

Congress also, with a just liberality which always characterizes it when legislating for those who are faithfully performing their duty, had voted $50,000 to pay the deficiencies due this very party. Not one cent of it was paid, as Congress designed, but it was improperly, if not illegally, diverted from its channel and given to the new commissioner, who expended it before he got on the ground, and incurred debts in addition far exceeding this sum. The persons for whom this money was intended, who had honorably sacrificed the certainty of private fortune to a sense of duty, were left in the field without pay and without subsistence.

It was hard to believe, and still harder to comprehend, that such an act of injustice could be perpetrated in a republican government. But when the fact became undoubted, and there was no longer hope, I called the small party together, and informed them that I should leave them to finish the line, as my instructions authorized me to do, in charge of a tried and faithful officer, Captain Hardcastle, and I would go to Washington in the first boat, to represent in person their situation. It was all that could be done in the case, and nothing else could be satisfactory after the clear breach of faith perpetrated twice, and in both instances, apparently, without the shadow of excuse.

On reaching Washington, I found a change had taken place in the office of Secretary of the Interior, and that the new Secretary, the Hon. A. H. H. Stuart, among the first acts of his administration, had sent relief to my party. By the aid of the means then furnished, the work was completed on the Pacific side, and the party returned to Washington in September, 1851.

Before leaving the Pacific coast, orders were sent me to turn over all the instruments, and the persons to whom they were turned over were directed to take them to El Paso, overland, by way of the junction of the Gila and Colorado.

The country to be traversed, as far as then known, was of the most difficult character, and almost impassable for wagons. The wages of teamsters and other laborers was $150 per month; mules, and all the means of subsistence, at a proportional price; and not a wagon was in the possession of the boundary commission. I reported all these facts, and showed the difficulty of complying with the order if we had funds; and, in addition to the natural obstacles interposed, it was well known there was not a cent in my hands; yet in the face of my remonstrances, the orders were reiterated, and, so far as my efforts went, were faithfully executed; but, as might be supposed, the persons who were charged with the performance of this duty utterly failed to accomplish it.

Foreseeing this result, and thinking it all-important that we should have a party on the ground in time to meet the commission at El Paso on the first Monday in November, the day on which they agreed to meet, and also that all the topographical information might be gained necessary to enable the commission to come to a proper decision on the point to be selected as the initial point of the boundary on the Rio Grande, I took the responsibility of ordering Lieutenant Whipple, with a suitable supply of instruments, to proceed to El Paso, by the way of Panama to New Orleans, and thence take the smooth road through Texas in wagons. But for this, the commission would have been at El Paso without an astronomical instrument, and without persons capable of using them, and wholly dependent upon the Mexican commission. A couple of weeks preceding my arrival from the Pacific, intelligence reached the department that the affairs of the new commission had fallen into great disorder at El Paso, and the Secretary of the Interior applied to the Department of War for me, by name, to be reassigned to the duty of astronomer, &c., to the boundary; but the intervention of the Bureau of Topographical Engineers caused another officer to be named in my place. I was quite satisfied to have nothing more to do with a mixed commission, governed by persons wholly unused to public affairs, and ignorant of the first principles of the scientific knowledge involved in the questions to be determined by them; but in little less than a year from this time, (September 13, 1851,) I was directed to proceed to El Paso and resume my duties, by taking charge of the survey of the boundary.

On the 15th I left Washington, and, after a dreary march across the prairies and uplands of Texas, reached El Paso in November, and resumed my duties in the field on the 25th of that month.

Having in view the difficulties of transportation over such a vast extent of country, uninhabited by civilized races, and infested by nomadic tribes of savages, I recommended, when in temporary charge of the commission, that the number of civil employés and assistants on the footing of officers should be reduced to fifteen. This recommendation was seemingly approved, yet on reaching the boundary commission I found that this number had been increased at one time to as many as one hundred and upwards; and although it had been greatly reduced, when I reached the scene of operations there were still a great many, the most of whom were unem-

ployed, and, with the exception of one or two, none were fitted for the service on which they were engaged; most of them ignorant of the first principles of surveying, and embroiled in feuds with each other, and arrayed in hostility either to the commissioner or to the head of the scientific corps.

The commissioner was absent on an expedition into Sonora, the commission was in debt, and not one cent was at my disposal to prosecute the survey. Beyond running an erroneous line a degree and a half west of the del Norte, and starting a party, with limited means, under Lieutenant Whipple, to survey the Gila, and another to survey the Rio del Norte from the point established by the commissioner, nothing had been done.

The situation was one of extreme embarrassment; but finding officers and men sufficient who were willing to undertake the work upon credit, I immediately established an observatory at Frontera, one at San Elceario, and another at Eagle Pass, and placed two surveying parties in the field in addition to those already out. In carrying out this design I was much aided by Mr. Magoffin, an influential and wealthy citizen residing near El Paso, with whom I had made the campaign in 1846, which resulted in the conquest of that country.

Clear and distinct representations were made of the condition of things to the Department of the Interior, and recommendations made to reduce and re-organize the commission which had been formed by the preceding administration on a scale preposterous in magnitude and absurd in principle. It was oppressed with a multitude of officers, quartermasters, commissaries, paymasters, agents, secretaries, sub-secretaries—all officers wholly unknown to any well regulated surveying corps, and worse than useless by the conflict of authority which these officers engendered, and the enormous expense which the payment of their salaries and personal expenses entailed on the commission.

The sum of five hundred thousand dollars had been expended, and I can safely say that not more than one hundred thousand had been appropriately used in running and marking the boundary up to that time, and all the work that could be said to be fairly accomplished was that done by the first commission—the completion of the line from the initial point on the Pacific to the junction of the Gila and Colorado rivers.

At the same time that I wrote a full account to the Department of the Interior of the condition of affairs in the field, and urged the necessity of immediate re-organization and relief in money, I despatched a special messenger, Mr. Edward Ingraham, with thirteen rifles, through the Indian country, in the direction of the Pimo villages on the Gila, to see if any intelligence could be had of the commissioner, with a letter to him representing in urgent terms the necessity for immediate aid. I entertained the reasonable expectation that from one or the other of these sources help would be obtained; and so believing, I did not hesitate to make all the necessary purchases to prosecute the work.

Although the Rio Bravo, from El Paso to its mouth, has been frequently mapped, it will surprise many to know, that up to the time when I commenced the survey, by far the largest portion of it had never been traversed by civilized man. This surprise will, however, cease when the reader reaches that part of the report which treats of the physical geography of the country, and his eye rests on the sketches by which it is illustrated. He will then see the impassable character of the river; walled in at places by stupendous rocky barriers, and escaping through chasms blocked up by huge rocks that have fallen from impending heights, where, if the traveller should chance to be caught in a freshet, inevitable destruction would be the consequence.

The plan adopted for the survey was to touch the river at convenient intervals, accessible to wagons, determine those points astronomically, establish depots for the surveying parties, and connect the intervening spaces by lineal survey. I attended in person to the astronomical work and the establishment of the depots. Lieutenant Michler, and assistants Von Hippel and Chandler, were placed in charge of the three surveying parties, and to their able assistance I am much indebted for the successful execution of the plan.

It would subserve no useful purpose to recite the difficulties which we encountered in the prosecution of this work. Superadded to the physical obstacles to be overcome, the men became almost insubordinate from the long absence of the commissioner from the work, and his unpardonable neglect to furnish money for their payment. Some of them had not received any pay for eighteen months, and the commissioner was at that moment, with an equipage and corps of attendants, visiting the States of Chihuahua and Sonora, and the Geysers of California—places sufficiently distant from the line.

When at Presidio del Norte, about one-third of the way down the river, the men, disgusted with long-deferred "promises to pay," became very mutinous; and on one occasion, I was obliged to put down a riot in my camp, single-handed, and at the risk of being shot by an insubordinate fellow, insane from the effects of the intoxicating mezcal. Shortly after, a whole party rebelled and refused to proceed further. Fortunately, at this moment I received, by an express sent out to intercept the mail from San Antonio to El Paso, an order from the Secretary of the Interior, authorizing me to draw on the department for a limited amount of funds. At this time, there was passing from Chihuahua to San Antonio a return merchant train with $5,000 in specie, which I obtained and turned over to the person acting as disbursing agent. With this sum I was enabled to pay off a portion of the men, and discharge the disaffected.

It was not until late in the fall of 1852 that we reached Eagle Pass (Fort Duncan) with the survey, having encountered no disaster, except the suspension of the work of Mr. Chandler's party, which was wrecked in the Cañon of the Rio Bravo, one hundred and twenty miles above the mouth of the Pecos. In the mean time, Mr. Michler's party had carried the survey from the mouth of the Pecos to Loredo.

At this stage of the work, just one year after my return to it, I received the first letter or notice of the commissioner, who sent me a check for twelve thousand dollars, which was handed over to Mr. Tansill, the disbursing agent, who, before he completed the negotiation of the note, received notice that it was dishonored. The work was, at the same time, inconvenienced by our receiving intelligence that the check for five thousand dollars was repudiated at Washington, which I had drawn upon the faith of the written order of the Secretary of the Interior, and which had been cashed by an unsuspecting and honest American merchant.

I considered that any attempt to push the work further, under the circumstances, was not called for on my part. The following letters were addressed to the commissioner, and all work was suspended except that of myself and personal assistants:

CAMP NEAR FORT DUNCAN, *October* 30, 1852.

SIR: I received your two checks—one for $12,000, the other for $8,000. The merchants here refused to cash them, alleging that similar drafts had been protested in Washington.

Unfortunately, a few days afterwards, notification was served on me, through one of the leading houses here, that a small draft drawn by me, under the authority of the Secretary of the

Interior, at Presidio del Norte, and without which the work would have been suspended at that point, had also been protested.

The protest was dated after the deficiency bill and the appropriation bill had become laws of the land. This settled the business. I had before this sent an agent to San Antonio to see what could be done, and unofficial advices are this day received, informing me the largest draft has fallen into hands of persons having, I know, large and just claims against the commission; so the whole object of my requisition, which was to have twenty thousand dollars here in cash to discharge and reorganize parties concentrating on this point, is defeated.

I made the requisition for that limited amount, supposing you, of course, would follow on immediately and join me here. Under these circumstances, seeing the work about to be suspended and myself placed in so false a position, I immediately, on the receipt of the notification that my draft was repudiated in Washington, despatched Lieutenant Michler to ascertain the cause, and correct, if possible, the delinquencies.

I have now been one year on this work without receiving a dollar from you, and have been obliged to sustain it by a system of credits, promises and threats, wholly unknown to our government. Considering the munificent appropriations made by Congress, I cannot think the survey has received anything like its just proportion of the funds.

I received by mail your letter informing me you could not keep your engagement to meet me at this place; in consequence of which I have this day made a requisition for funds directly on the Department of the Interior, to prevent, if possible, a suspension of the work, and the scenes of disorder that must ensue if the parties collecting here are detained for want of means to send them on or discharge them.

I regret to learn by your letter that you have taken Mr. Radziminski and assistants with you, as two opportunities presented themselves since your arrival, and that of Mr. Whipple, at El Paso, by either of which he and his party could have joined us with ease and safety.

I regret to learn, also, from Lieutenant Whipple, that you have not seen proper to furnish him with funds. I understood your letter as agreeing to my proposition that it was necessary to furnish with funds each chief of party.

So many and so complicated have become the difficulties growing out of the long continued absence of yourself, in whom rest all the moneyed powers of the commission, that I would, to obviate them and other difficulties, leave my work and go to any point to meet you; but your letter is indefinite both as to time and place of meeting, and, for the present, I content myself with sending this to the place you name as the most probable to meet you—Camargo, or rather Ringgold barracks, the American post opposite.

My estimate for the year 1852 was $90,000; not a cent too much, though many of the items in that estimate would, from my increased experience, now be changed. This estimate was made at El Paso in duplicate, accompanied by letter. One copy was directed to you at, I think, San Diego, and the other copy was directed to you through the Department of the Interior. If you were not in place to receive it, that is no fault of mine, and surely can never be used as a reason for the distressing and unusual condition in which I am placed, both personally and officially, by the total failure to keep the working people of this commission supplied with a portion of the munificent funds voted by Congress for this work.*

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* For a statement of all the money voted by Congress for this survey, see statement at the end of this chapter.

At El Paso, to avoid stopping the work, and to relieve the immediate necessities of individuals, I certified to the correctness of accounts, and the individuals sold them to shavers and brokers.

This necessity should never occur in government work, as it leads to speculation, and is injurious to the credit of the government.

Should this meet you, I desire you will send me, with as little delay as possible, twenty thousand dollars in cash, and cause thirty thousand to be placed to my credit either in New Orleans or at Fort Brown. Should you do so, the requisition on the government, if complied with, will not be used.

I am, sir, very respectfully, your obedient servant,

W. H. EMORY.

John R. Bartlett, Esq.,
United States Commissioner.

Ringgold Barracks, *December* 20, 1852.

Sir: The drafts drawn by me, under authority of the Secretary of the Interior, and the drafts sent me by you from El Paso, were all protested. Notice of this, and other circumstances beyond my control, caused me, in effect, to stop operations about the 5th of November, since which time I have been, as directed by the Secretary, awaiting your arrival; so that we have, in fact, been at work one year, without receiving a dollar from the government; and many of the employés have not been paid for a much longer time. As stated to you in conversation, at Presidio del Norte, a panic seized a large number of the men—first, with the idea that they never were to be paid, and, second, with a fear of the Indians.

Being in a country wholly remote from any aid, I found it absolutely necessary to keep the men in service; and upon the faith of orders from the department, and the expectation of soon meeting you, I promised they should be paid and discharged at Fort Duncan. I desire now to take the only remaining step left to enable me to redeem that pledge, and to request, if there is a dollar left, it may be distributed among these men.

Enclosed is a list of officers and men in the service, and the amounts due to each up to November 20, 1852. Subsequent revision of the accounts may show a slight alteration.

The total amount of this list is	$16,439
The pay, &c., up to this time will be, in addition	7,000
To which is to be added a check for $12,000 drawn by you in my favor, and turned over to T. W. Tansill, quartermaster of the boundary commission, accepted by Messrs. Lewis & Groesbeck, expended in drafts by Mr. Tansill, and subsequently repudiated by Messrs. Lewis & Groesbeck	12,000
There is also due, chiefly in San Antonio, about $8,000, the amount of the drafts drawn by me, under the authority of the Secretary, not accepted	8,000
	43,439

I think it unnecessary to make a requisition on you for a further prosecution of the work until the above demands are satisfied.

I am, sir, very respectfully, your obedient servant,

W. H. EMORY,

Bt. Maj. U. S. A., Chief Astronomer Survey B. C.

J. R. BARTLETT, Esq., *U. S. Commissioner.*

After making the best arrangements I could to satisfy the various demands of the men and other creditors of the commission, I repaired to Ringgold barracks, where it was reported the commissioner would strike the boundary on his return trip from Mexico. There I awaited his arrival, occupying my time by establishing an observatory, to be used in the event of the resumption of the work.

On the 20th of December the commissioner arrived; and finding that no security could be given for the payment of the debts already contracted, or for those necessary to be contracted in the future prosecution of the work, I did not hesitate to avail myself of the authority granted by the Secretary to suspend the work of the survey of the river. A resolution of Congress had already suspended the survey west of the river.

After turning over all the property and papers of the commission, except the instruments and notes of the survey, I repaired to Washington city, and commenced the computation of the field-work as far as it had been completed.

In the month of March, 1853, Congress appropriated a sum of money to complete the survey of so much of the Rio Bravo as constituted the boundary, and to prosecute the office-work of the survey. The commission was immediately reduced and reorganized. A new commissioner (being the fourth) was appointed.

The parties were organized by me, and placed in the field in less than a month; and by the middle of December, 1853, all the field-work was completed within the time and for a less amount than had been estimated.

The following is the organization under which the work of the old boundary was concluded:

Robt. B. Campbell, U. S. commissioner.
Lucius Campbell, secretary.
W. H. Emory, chief astronomer and surveyor.
G. C. Gardner, assistant.
J. H. Clark, do.
Lieut. Michler, corps Topographical Engineers, in charge of surveying party.
E. A. Phillips, assistant.
Ed. Ingraham, do.
Chas. Radziminski, in charge of surveying party.
Thos. W. Jones, assistant.
Jas. H. Houston, do.
Arthur Schott, in charge of surveying party.
M. Seaton, assistant.
J. E. Weiss, do.

Capt. George Thom, corps Topographical Engineers, was left in charge of the office-work, assisted by assistants Chandler, Herbst, Thom, Wheaton, and O'Donoghue.

The collation of the geological work was left in charge of Drs. Hall and Parry; that of the zoological, in charge of Prof. Baird; and the botanical, in charge of Prof. Torrey.

Lieut. Michler was assigned to the unfinished work above Eagle Pass, Schott to the survey from Laredo to Ringgold barracks, and assistant Radziminski to the survey from Ringgold barracks to the mouth of the Rio Bravo; whilst I, with assistants Gardner and Clark, determined astronomically the points along the boundary, intended as checks upon the accuracy of the surveys.

Before the completion of the work, the yellow fever made its appearance, and myself and several of the assistants were attacked—some on the line, and others after leaving it and reaching the northern shores of the Gulf of Mexico, where this disease raged with unusual violence.

No serious inconvenience was experienced, however, in the prosecution of the work, from this cause, and nothing happened to interrupt the harmonious and rapid execution of the field work, but the melancholy loss of assistant Thomas Walter Jones, who was drowned in the Rio Bravo by the upsetting of a skiff, in which he was returning to camp from his labors in the field, on the evening of 23d July, 1853. His body was found two days after, a few miles down the stream, and was buried by his afflicted companions at the rancheria of Dr. Merryman, on the banks of the Rio Bravo.

This ends the narrative of the operations in the field of the various commissions organized under the treaty of Guadalupe Hidalgo.

It is proper for me, however, before closing this chapter, to refer to a publication issued by Mr. J. R. Bartlett, one of the late commissioners on the part of the United States, which professes to give an accurate account of the affairs of the commission. It is not my purpose to review that work, and expose its errors, but simply to correct some statements affecting myself.

Mr. Bartlett's principal achievement on the boundary was the agreement with General Conde, the Mexican commissioner, fixing the initial point on the Rio Bravo, in the parallel of 32° 22′, instead of a point as laid down on the treaty map about eight miles above El Paso, which would have brought it to the parallel of 31° 52′. That agreement is no less remarkable than the adroitness and success with which Mr. Bartlett convinced the authorities at Washington of its correctness.

The question has been so thoroughly discussed, that a reproduction of it here is not called for. It is sufficient to say, that it was disapproved by the astronomer and surveyor on the commission at the time, and was finally repudiated by the government. Mr. Bartlett, in his account of the matter, states I was ordered to sign the map of his initial point, and that I did sign it. But he does not state what was the purport or meaning of my signature, nor does he give my letter which reported the circumstances to the government; but only an extract of that letter, selecting paragraphs of it to suit his own views. I here supply the deficiency by giving the letter in full, and the agreement signed by myself and Mr. Salazar, the Mexican commissioner, who succeeded General Conde. It will be seen that the Secretary of the Interior took the responsibility of making the action of the two commissioners final, thereby rendering the joint commission authorized by the treaty, as I understood it, a nullity. In view of such an interpretation, my signature as surveyor was only required, as alleged, to perfect the *official documents;* the words of the order were, "*You will sign the map of the initial point agreed upon by the two commissioners.*"

By reference to the treaty it will be seen that any agreement of the kind required the action of the joint commission, and that the joint commission was to be composed, not only of the *two* commissioners, but of the two surveyors also.

I refused to recognise the act as that of the joint commission, and signed the map as the order directed, carefully and studiously attaching a certificate that it was the initial point of the two *commissioners;* and to prevent the possibility of misconstruction, an agreement in writing was entered into with Mr. Salazar, and our signatures attested by witnesses, showing that the map was only that of the boundary agreed upon by the two commissioners, and nothing else.

This course, while it permitted me to obey a specific order in writing from a superior, left the government free to act, and repudiate the agreement by the two commissioners, as it subsequently did.

It is evident that any other course would have resulted in committing the government, irretrievably, to an erroneous determination of our southern boundary. It is but just, however, to Mr. Bartlett, to state, that so far as the facility for a route for a railway to the Pacific was considered, the line agreed to by him was no worse than that claimed by his adversaries. My own reports, based upon previous explorations, had presented the whole case very clearly to view. Yet these reports were overlooked, and it was ignorantly represented that while Mr. Bartlett's line lost the route for the railway, the other line secured it. I will not here fatigue the reader by a topographical description of the country, showing where the obstacles to a railway route exist; but he will see by a glance at the map, that the practicable route so adjudged by myself, and by other officers who retraced my steps and re-surveyed this country, is to the south of both these lines of boundary claimed under the treaty of Guadalupe Hidalgo.

In this same book, Mr. Bartlett claims to have produced the first correct map of the Gila. He labors to place himself on the footing of an explorer of a new country, and only mentions previous explorers of that river to repudiate them.

On page 192, volume II, Mr. Bartlett, in his personal narrative, says: "It is also proper to state, that Lieutenant Whipple and Mr. Gray found the bend of the river to be much greater than is laid down by Major Emory on his map." It would have been no more than truth required, for Mr. Bartlett to have stated, what I expressly state in my printed memoir accompanying this map, that I did not explore this bend, but laid it down from conjecture. It is a small affair, subtended by a chord of thirty or forty miles. I passed over the chord, and not the bend, and so stated.

The survey of that bend is given in the map of this report, and it will be seen it differs from that laid down by Mr. Bartlett as the first correct map of the Gila. A comparison of his map with that published by me in 1846 will show that, with the exception of this bend, which he has laid down erroneously, he has copied literally my map of 1846, even those parts laid down conjecturally.

The reconnoissance of the Gila made by me in 1846 was under adverse circumstances, made, I may say, in the face of the enemy; yet it has stood the test of re-survey, and Mr. Bartlett has added to the injustice of attempting to depreciate my labors, the meanness of appropriating them.

On the same page, and in the same spirit, Mr. Bartlett says: "Mr. Gray, in his official letter to the Secretary of the Interior, from San Diego, says that many errors of others who have been along this river, in astronomical observations, were corrected by Lieutenant Whipple."

As I am the only person who ever made an astronomical observation on the Gila, previous to

my sending Lieutenant Whipple there, who was one of my assistants on the boundary, I am the person referred to.

The points selected by him, and those selected by me in 1846, are not identical, and no survey connected them; they therefore, as a general rule, cannot be compared directly with each other. Fortunately, however, the only point determined elaborately by Mr. Whipple can be placed in direct comparison with my reconnoissance in 1846. By reference to my journal, published by Congress in 1847, it will be seen I observed with the sextant, in 1846, at a camp about one mile and a half south of the junction of the Gila and Colorado, and obtained for the—

Latitude of the camp.. 32° 44′ 09″
Longitude west of Greenwich.. $7^h\ 38^m\ 28^s.6$

Lieutenant Whipple, under my orders, determined the junction with a 36-inch transit, and a 46-inch zenith telescope, to be in—

Latitude.. 32° 43′ 32″.3
Longitude .... $7^h\ 38^m\ 11^s.8$

Upon this determination of Lieutenant Whipple's being recomputed by Professor Hubbard and myself, introducing the new element of the corresponding observations at Greenwich, furnished by Professor Airy, we obtained—

For latitude.. 32° 43′ 23″.3
For longitude .... $7^h\ 38^m\ 24^s.27$

Now, if we make allowance for this mile and a half, which was not accurately measured, we find a coincidence in the two results truly remarkable, considering that I used, in 1846, only a reconnoitring instrument, a small Gambey sextant.

The above will show that Mr. Bartlett had no authority, in fact, for what he states; and to show, further, that he has given currency to an insinuation neither justified by facts nor by reliable information within his reach, I give the following letter of Lieutenant Whipple, who made the re-survey of the Gila, and who is the only person from whom Mr. Bartlett could derive his information:

WASHINGTON, *June* 13, 1853.

DEAR SIR: Your note of this date communicates a paragraph from "Bartlett's Personal Narrative," stating that Mr. Gray, in his official letter to the Secretary of the Interior, from San Diego, relating to the survey of the Gila, says, "that many errors of others who have been along this river, in astronomical observations, were corrected by Lieut. Whipple."

If the above was intended, as you infer, to throw discredit on your astronomical labors in 1846, I do not hesitate to pronounce it unjust. *During the progress of the survey and afterwards*, I freely expressed my admiration of the general precision with which the Gila had been laid down upon the map from your astronomical observations.

I am, very respectfully, your obedient servant,

A. W. WHIPPLE.

CAMP NEAR FORT DUNCAN, *October* 1, 1852.

SIR: I have the honor to acknowledge this day the receipt of your letter enclosing me the commission of United States surveyor, for running and marking the line between the United States and the republic of Mexico.

Your letter enclosing the appointment was handed me on the 30th of January at Samalurca, in Mexico, together with a letter of instructions, and a copy of instructions to the commissioner, dated November 4, defining the duties of the surveyor, and directing me to be governed accordingly.

I have been hoping from that day to this to have an interview with the United States commissioner, but have not, in consequence of his absence, nor have I received any communication from him whatever, until the day on which I broke up my camp at the Presidio del Norte, August 20. I received by express a letter from him, a copy of which is herewith enclosed, by which it will be seen he arrived at El Paso on the 16th of August, and proposed to meet me at this place.

There are several points in these instructions, based, as I have reason to believe, upon erroneous information conveyed to the Secretary; and as I believe the commissioner to whom they refer as directly as to myself will concur with me in the recommendation I design making, I have, for obvious reasons, deferred making them until his arrival, and shall defer doing so with the hope of at length meeting him. In the mean time I have pushed the survey with unceasing diligence and economy; and many subjects now press so closely, that it is necessary for me to communicate directly with the Secretary, and no longer await the arrival of the commissioner.

I have carried the survey down as far as Laredo, with the exception of a small space still to be covered between the great Chizo Cañon and the Rio San Pedro. On this portion two parties are now operating. One was disbanded and reorganized by me in consequence of a panic which seized it in regard to the Indians; and the other has within these last few days been surrounded by Indians, forced to abandon the survey, retire to the hills, and send in for aid.

To the first I was obliged to give the entire escort, and pass through the infested country myself without a soldier; to the last I gave all the spare men I had; and it was also furnished, at my request, by Major Lamotte, commanding at Las Moras, with five infantry soldiers. This region is the thoroughfare for all the bad Indians on the frontiers. I have passed through it myself without damage, and I hope the two parties will do the same; but enough has happened to justify me in having in previous communications so often urged the necessity of additional escort, and I have now respectfully to request that the Secretary will apply to the War Department to furnish a company of soldiers to escort either of these parties should they be again driven back; below here no escort will be required.

The parties have each been so well reinforced, I do not believe either of them will have any further trouble, for all work bravely and cheerfully; but if they should, it would cause much delay unless a company of soldiers is held in hand to send them.

On my reaching the ground to take charge of the survey, November, 1851, I found that Mr. Bartlett and the acting surveyor had agreed upon the initial point, 32° 22′, and that a great stone monument had been erected marking the point, and having the usual inscriptions, and the names of the American and Mexican commissioners, astronomers, and surveyors; and Mr. Salazar informed me this had been hastened at the urgent request of the American astronomer and surveyor.

I also found that articles of agreement, based upon the letters of instruction from the commissioner to Col. Graham, my successor and predecessor as chief astronomer, had been entered into with Mr. Salazar for the survey of the boundary, and the survey had been commenced at the initial point, 32° 22′, by Col. Graham.

On the 30th January, 1852, while on my route west of El Paso, in pursuit of the commissioner, I received unexpectedly, and certainly unsolicited, the letter of appointment as United States surveyor, and your letters of instructions, one to myself and a copy of the letter of instructions to Mr. Bartlett, dated November 4, 1851, in which it is directed that "should the surveyor at any time differ with you [the commissioner] on any question connected with the survey, he [the surveyor] will defer to your [the commissioner's] opinion until the case is submitted and decided by the department.

The surveyor came out long after the initial point was agreed upon, and the monument erected and the line begun, relieved the acting surveyor, and protested against the point. With the protest and the views of the commissioner before him, both sides it is presumed fairly stated, the honorable Secretary instructed the surveyor to sign the maps; but before the instructions reached him, he was relieved, and I was appointed in his place, with the same instructions.

I therefore considered the matter as settled, and the action of the government as final. "The official documents which have been prepared for the purpose," referred to in my letter of appointment and instructions, never having been presented, no action has been taken in the matter definitely and finally to "settle this important point." I quote from my instructions, for, as I shall presently show, it has, by the views taken of the subject by both sides, ceased to be an important point.

But I have done this in compliance with the letter and spirit of my instructions. Mr. Salazar, the Mexican commissioner and surveyor, met me at the Presidio del Norte, August 1st, to sign the maps of the Rio Grande forming the boundary. Neither party had the maps properly prepared, nor was Mr. Salazar at all prepared in money or means to go on with the work at the rate I was progressing. I had already signed, conjointly with him as astronomer and surveyor, the only maps fit for signature, but he remained pressing me to sign other maps which involve incidentally the initial point agreed upon by Mr. Bartlett, Mr. Conde, Mr. Salazar, and Mr. Whipple, from which Colonel Graham had started his survey of the river. I therefore, on the 28th August, signed the maps according to my instructions, with the reservation contained in the paper, a copy of which is herewith sent, marked "A," signed conjointly by Mr. Salazar and myself, and the statement therein referred to setting forth on the face of the maps that it was the "*boundary-line agreed upon by the two commissioners, April* 20, 1851."

I presume it was never intended I should give my certificate, as astronomer and surveyor, to the correctness of the determination of a point which had been determined by the observations of others, and without consultation or advice of mine. On the other hand, I do not for a moment doubt the power of the government to instruct me on the subject, or hesitate as to my duty to obey its mandates, which I understand as requiring me only to authenticate the initial point agreed upon by the commissioners of the two governments.

In reference to the importance of the point, I think it as well to state that the line agreed upon by the commission, April, 1851, is about 33′ north of the line contended for, as that laid down by Disturnell's map, but it reaches about 16′ of arc further west; and as both lines run 3° of longitude west, the difference of territory is 3° of longitude multiplied by about 40′ of latitude, each having a middle latitude that may, for the purpose of computation, be assumed at 30°. Neither line gives us the road to California, and the country embraced in the area of the difference, with the exception of a strip along the Rio Grande about nine miles long and from one to two wide, is barren, and will not produce wheat, corn, grapes, trees, or anything useful as food for man, or for clothing.

Neither line will give us a channel of communication for posts along the frontier, without which it is impracticable to comply with the XIth article of the treaty, which enjoins the United States to keep the Indians out of Mexico.

When originally on the work, before the point was determined, having a knowledge of the country from previous reconnoissance, I had the honor of asking the attention of your predecessor to this very subject, in a communication dated April, 1849, San Diego, California, which was subsequently printed by the Senate. I then pointed out what I believed to be the only view taken of the treaty, which would have given us the road, it being, in truth, the only important matter involved in the question. No notice was taken of this, and I was superseded in my command until restored by you, although Mr. Clayton, the Secretary of State, had declined, on my application, to relieve me, on the ground of my knowledge of the particular duties to which I was assigned.

On my return to the work, both governments having been committed in the matter by the commission, the time was passed when anything could be effected with the Mexican commission.

It is not pretended that the view there taken of the treaty is as close a legal construction as that taken since; but it is the only one which could have given us a wagon road from the Del Norte to the Pacific by way of the Gila river. And it is believed that, if this point had been urged before discussion took place, or before either party had committed itself, the obvious advantages to both would have secured its adoption.

I have the honor to be your obedient servant,

W. H. EMORY.

The Hon. SECRETARY OF THE INTERIOR.

I give here a copy of my letter of April 2, 1849, which, had it received attention, would have been the means of saving much controversy and expenditure of time and money:

BOUNDARY COMMISSION, SAN DIEGO, *April* 2, 1849.

SIR: Paper marked "A" will exhibit to you the adoption of my determination of the astronomical line forming the boundary between the United States and Mexico, from the initial point on the Pacific to the junction of the Gila and Colorado rivers, by the Mexican astronomer and surveyor, Señor Don José Salazar y Larregui. The line passing through the five points stated in that paper, as determined by me, is in view of the Tecaté mountain, thirty miles distant, and Señor Salazar undertook to establish on the Tecaté a signal in the prolongation of this line, and has succeeded in doing so; and the same has been verified under my orders.

Knowing the long time that must elapse before the monuments arrive, I have, in conjunction with Mr. Salazar, to secure this line beyond all cavil, and for the convenience of property holders on either side, caused monuments of a pyramidal shape, twelve feet at the base, and twelve feet high, composed of stones and earth, to be erected at the points established. These extend over a space of thirty miles, and embrace all the settled portions. I have bound the government for the payment of one-half the cost of the monuments, the Mexican commission paying the other half.

You were apprized in my last despatch that this commission, when I received the charge of it, was without one cent of money, without a mouthful to eat, and without a hoof or wheel for transportation; and that I was deprived of the only means of doing anything, by being deprived at the same time of military command.

I have not been instructed to estimate funds for the past or future. I have no means of estimating the debts of the commission, but presume this has been done by the late commissioner. I think it proper, however, to send an estimate herewith of funds required by Brevet Captain Hardcastle, to enable him to carry out his instructions. I think it also proper to inform the Department, for the benefit of the operators from the "Paso del Norte," that authentic information has reached here, that the Mexican frontier towns of Fronteras and Santa Cruz, which have always been counted on by the officers of the commission to furnish supplies, have been ravaged by the wild Indians, and deserted by the inhabitants, and the means of subsistence of the Pimos Indians have been eaten out by the emigrants. In addition to the American emigration, a dense stream of "Sonoreans," and other Mexicans, is now pouring over a portion of the same route into California, desolating the herbage and means of subsistence as they pass. Five thousand and upwards have already penetrated the country this season, and it is estimated by intelligent men that fifteen thousand more are in movement in the same direction.

In connexion with this same subject, and reverting to my despatch No. 2, I presume enough was then said to satisfy you that the expedition should not move from the "Gila eastward." The fact alone, that all it may accomplish, if it can

accomplish anything, between the mouth of the Gila and the "Paso del Norte," beyond that of overcoming space, will be by the movement of the Mexican commission, growing out of the action of the joint commission of an ex parte character, and therefore of no value. But, in addition to this, we may lose a great advantage by pushing the survey in that direction—no less than the only practicable route for a railway over the Sierra Madre; which route is near the 32d parallel of latitude. That supposed to have been recently discovered by Lieutenant Simpson I believe impracticable. Had that intelligent officer come further "westward," he would have found an insurmountable barrier.

By pushing the survey eastward, and looking for a branch of the Gila which shall fulfil the conditions of the treaty—the first to intersect the boundary of New Mexico—you will inevitably be made to strike that boundary far north of the parallel of the copper mines; because all the streams south of that parallel, having their sources in the Sierra Madre, running towards the Gila, disappear in the sands before they reach Gila, except in cases of unusual freshets. Working eastward, their almost trackless beds must escape the notice of the keenest explorer. Working from the "Paso del Norte" northward and westward, you strike the sources of the streams themselves; and although they may disappear many leagues before reaching the Gila, they may nevertheless be affluents of that river, and fulfil the condition of the treaty.

Another view of the case may also be taken. The inaccuracy of the map upon which the treaty was made, and which thereby became a part of the treaty, is notorious. It is also known to all who have been much in the frontier States of Mexico, that the boundaries of those States have never been defined on the ground, and are unknown. This is particularly the case of the boundary betwixt New Mexico and Chihuahua. In this condition of things the commissioners must negotiate, and they may adopt the 32d parallel of latitude, until it strikes the San Pedro, or even a more southern parallel of latitude. This would give what good authority, combined with my own observations, authorizes me to say is a practicable route for a railroad—I believe the only one from ocean to ocean within our territory.

Another consideration is, the treaty makes the Gila for a certain extent the boundary. The Gila does not always run in the same bed; whenever it changes the boundary must change, and no survey nor anything else can keep it from changing. The survey of that river, therefore, as it fixes nothing, determines nothing, is of minor importance. It forms of itself a more apparent and enduring monument of the boundary than any that can be made by art; and on the principle that that which is of the greatest necessity should be done first, the line from the Paso del Norte, until it strikes a branch of the Gila, would seem to demand the first attention.

It is but just to say these are not views recently adopted by me; they were entertained and expressed before leaving Washington and since, and I urged that none but the astronomical party, and just as much of the commission, should be sent to the Pacific side as was necessary to fulfil the conditions required by the letter of the treaty.

Very respectfully, your obedient servant,

W. H. EMORY.

Hon. T. EWING, *Secretary of the Interior.*

[*Letter referred to in the note on page* 14.]

OFFICE UNITED STATES BOUNDARY COMMISSION,
Washington, April 23, 1856.

SIR: In answer to your instructions of April 22, predicated on a resolution of Congress, received this day, I have the honor to submit the following table, showing the several appropriations made by Congress for the survey of the boundary line between the United States and Mexico, as established under the treaty of Guadalupe Hidalgo:

U. S. Statutes.		Date of law.	Object of appropriation.	Amount appropriated.
Vol.	Page.			
9	301	Aug. 12, 1848	Running and marking boundary line under treaty of Guadalupe Hidalgo	$50,000 00
9	426	May 15, 1850	Do.....do.....do.....do.....do..	50,000 00
9	541	Sept. 30, 1850	Do.....do.....do.....do.....do..	135,000 00
9	614	March 3, 1851	Do.....do.....do.....do.....do..	100,000 00
10	17	July 21, 1852	Do.....do.....do.....do.....do..	80,000 00
10	95	Aug. 31, 1852	Arrearages of boundary commission	25,000 00
10	140	Dec. 23, 1852	Running and marking boundary line below El Paso, including expenses already incurred	120,000 00
10	209	March 3, 1853	Arrears due Major Emory's party	20,000 00
10	209	March 3, 1853	Expenses of Lieut. Whipple's party	6,000 00
10	209	March 3, 1853	Running and marking boundary line under treaty of Guadalupe Hidalgo	93,012 00
10	296	May 31, 1854	Arrearages prior to July 1, 1853	50,000 00
10	296	May 31, 1854	Engraving maps, views, &c., of boundary survey	10,000 00
10	570	Aug. 4, 1854	Compensation of officers, office-work, &c	38,100 00
10	664	March 3, 1855	Engraving maps, views, &c., of boundary survey	10,000 00
			Total	787,112 00

Of the above amount, the disbursement of only a very small portion came under my direction or within my knowledge. The item of $38,100 for office-work and the two items of $10,000, each were disbursed by Captain Thom under my immediate direction. Of the first sum, there was, January 1, 1856, a balance untouched of $24,445 54; and of the two last sums a balance of $12,900. As far as my authority has extended, there have been no defalcations.

I have also to submit a table showing the appropriations made by Congress for the survey of the boundary between the United States and Mexico, as established under the treaty of December 30, 1853.

U. S. Statutes.		Date of law.	Object of appropriation.	Amount appropriated.
Vol.	Page.			
10	568	Aug. 14, 1854	Running and marking boundary under treaty of December 30, 1853	$168,130 00
10	661	March 3, 1855	Do ... do ... do ... do	71,450 00
			Total	239,580 00

Of the amount appropriated for the survey, &c., of the boundary under the treaty of December 30, 1853, most of it was disbursed by myself, and a portion by Lieut. Michler; and there remained, on the 1st of January, 1856, in the hands of the assistant treasurer of the United States at New York, to my credit $42,004 59
In the hands of Lieut. Michler 5,000 00
In the treasury of the United States at Washington, not drawn 51,450 00

Total 98,454 59
Total from above 37,345 54

Grand total 135,800 13

And I have further to report that no defalcations have occurred in those under my orders.

I have the honor to be your obedient servant,

W. H. EMORY, *U. S. Commissioner.*

Hon. Robert McClelland, *Secretary of the Interior.*

The field-work of the boundary survey under the treaty of 1850, confided to my charge, was finished within the time estimated by the government. It will be seen from the above statement that the whole work will be completed at an expense much within the appropriation made by Congress.

CHAPTER II.

PERSONAL ACCOUNT CONTINUED.

ORGANIZATION OF COMMISSION UNDER TREATY OF DECEMBER 30, 1853.—TRIP TO EL PASO DEL NORTE.—JOURNAL OF JOINT COMMISSION.

On the 15th August, 1854, I received from the President of the United States, through the Hon. Robt. McClelland, Secretary of the Interior, the appointment of commissioner "to survey and mark out upon the land the dividing line between the United States and the republic of Mexico, concluded on the 30th of December, 1853, the ratifications of which were exchanged in the city of Washington on the 30th day of June, 1854." At the same time I received special instructions from the Secretary of the Interior, and a copy of the treaty, which will be found in the appendix.

The terms of the treaty required that each of the two governments should nominate one commissioner, and that "the two thus nominated should meet in the city of El Paso del Norte three months after the exchange of ratifications of the treaty, and proceed to survey and mark out the line," &c.

To reach El Paso del Norte in the time required by the treaty, (October 1st,) it would have been necessary to leave my outfit to take care of itself, and travel post-haste. Knowing well the character of the country in which that service was to be performed, I concluded to send forward a special messenger to meet the Mexican commissioner, and to remain and give my personal attention to the outfit. Everything in the way of astronomical and surveying instruments, transportation, arms, provisions, and medicines required for the campaign, was to be provided in advance, and shipped from New York.

By employing men to work night and day, and shipping my wagons, at great expense, on board the passenger steamers, I was enabled to land the whole outfit at Indianola, Texas, by the 25th of September.

On the night of the 18th September, while crossing the Gulf, a terrific tornado swept the coast, and every wharf in Matagorda bay, except that upon which a portion of our outfit was landed, was carried away, and the town of Matagorda itself levelled with the ground. We found at Indianola a number of mules belonging to the old commission; but they were in such miserable condition, I determined to send them up to San Antonio with the empty wagons, and hire transportation for the supplies which had been purchased in New Orleans and safely landed at Indianola. The low country between Indianola and Kilpatrick's, a distance of twenty miles, was inundated, and the roads so bad, that the contractor for the transportation of our supplies was twenty days passing as many miles. The yellow fever was then prevalent, and added much to our embarrassments, several of our party having been stricken down at the moment of entering upon a distant and arduous service. I was, however, so thankful to have escaped without damage the tornado of the 17th–19th of September, which proved so disastrous around us, that every other adverse circumstance seemed trifling.

On the 25th of October I had succeeded in enlisting and equipping sixty or seventy men for the service, and in purchasing the necessary number of animals.

The escort, consisting of a company of the 7th infantry, commanded by Brevet Capt. E. K. Smith, reported itself in readiness on the same day, and on the next we took up the line of march for El Paso.

Before leaving Washington I organized, with the assent of the Secretary, a party, under Lieut. Michler, to proceed to California and work from the Pacific side to meet me.

When the commission took the field the following was its organization; and this organization was continued with scarcely a change until the successful conclusion of the field-work, in the fall of 1855:

W. H. Emory, U. S. commissioner, chief astronomer and surveyor.
Chas. Radziminski, secretary.
Lieut. Chas. N. Turnbull, corps Topographical Engineers, general assistant.
M. T. W. Chandler, do.
J. H. Clark, principal assistant astronomer.
Hugh Campbell, assistant.
Winder Emory, clerk.
Maurice Von Hippel, principal assistant surveyor.
Chas. Weiss, assistant surveyor.
F. Wheaton, reconnoitring assistant.
Wm. Likens, assistant in charge of commissary stores.
Jas. Houston, assistant.
David Hinkle, do.
Benj. Burns, assistant in charge of instruments.
Lieut. N. Michler, corps Topographical Engineers, in charge of party operating from the Pacific side.
Arthur Schott, assistant to Lieut. Michler.
E. A. Phillips, do. do.
John O'Donoghue, do. do.

Capt. George Thom, corps Topographical Engineers, with a few civil assistants, was left in Washington in charge of the office, to reduce the observations and project the work done under the old commission.

Besides the above, there were employed in the different parties about one hundred men, in the various capacities of teamsters, laborers, cooks, servants, and arrieros.

The infantry escort accompanied the commission from the time of leaving San Antonio until our return to El Paso. From that point to San Antonio it was commanded by Lieutenant Cummins. At El Paso, on the outward journey, we received an accession to the escort of thirty dragoons, commanded by Lieutenant Hastings. Lieutenant Michler was escorted by a detachment of artillery soldiers, commanded by Lieutenant (now Captain) Patterson. In addition to his military duties, Captain Smith aided me materially in the business of the boundary survey.

The first part of the journey from San Antonio to El Paso was very slow, in consequence of the heavy rains, which made the roads in many places almost impassable for our heavily laden wagons. Beyond Devil's river we found the roads good, water and grass plenty, and succeeded at last in reaching El Paso in time for the Mexican commission.

We did not see an Indian on the route, although in front and in rear of us they were committing depredations along the whole road.

At Cantonment Blake, on the Devil's river, they waylaid and killed a couple of soldiers; at Live Oak they drove off, in open day-light, all the animals of the military post temporarily established at that point. At Fort Davis, we found they had attacked a party and killed a sergeant and musician; just beyond, at Dead Man's Hole, they attacked the mail party, and would probably have handled them severely, had not another party coming in the opposite direction, joined them at the critical moment.

On arriving at the cañon about seventy miles below El Paso, I left my escort and train, with directions to proceed slowly up the river, while I went to make such arrangements with the Mexican commissioner as would enable me to move the parties directly on the new line, and commence operations.

I accomplished this with the Mexican commissioner satisfactorily; although winter had now set in with severity, and the small-pox showed itself in our camp, and we had just accomplished a journey of sixteen hundred miles, every assistant and man took the field as cheerfully as if he had just left his barracks.

Each one of the principal assistants was selected upon the estimate of his professional abilities, derived from personal knowledge, and I had no reason to make any changes of importance from the beginning to the end of the work. My own expectations, and I hope those of the government, were entirely fulfilled in the manner in which the work was accomplished. Under all circumstances—during the cold winter exposed upon the bare ground of the bleak plains, and in the summer to the hot sun blazing over the arid desert—every order was executed with fidelity, and the work was completed within the time, and largely within the amount appropriated by Congress. We passed the entire width of the continent and returned with the loss only of two men, and without losing a single animal, (except those worn out by service,) or suffering a stampede by the Indians; at the same time that our co-operators on the Mexican commission were twice robbed of every hoof by the Apaches, and extensive losses were sustained by other detachments of United States troops, and by our citizens traversing this region.

I close this short personal account by giving the journal of the joint commission, composed of Señor Salazar and myself. It will be seen, that throughout the whole expedition the utmost harmony prevailed, and I take this occasion to express, not only for myself, but for the whole American commission, the pleasant recollection of the agreeable intercourse which existed between ourselves and the Mexican commissioner, and the officers under his command. Señor Salazar failed to receive from his government means to carry on the work with the rapidity contemplated in the agreement with myself, and he was twice crippled in his operations by the depredations of the Indians.

JOURNAL OF THE JOINT COMMISSION.

PASO DEL NORTE, *December* 4, 1854.

The undersigned, commissioners respectively on the part of the United States of America and of the Mexican republic to run and mark the boundary line between the two countries, according the treaty concluded in the city of Mexico on the 30th day of December, 1853, met informally in the town of El Paso del Norte on the 2d instant, and on the 4th, the date of this joint record of their proceedings, they had another meeting in the same town, when, having exchanged credentials, they proceeded to discuss and arrange the business upon which they were called together by their respective governments.

Both parties being ready to commence operations, and there being no difference of opinion upon the scientific and practical manner of determining the boundary between the two countries, it was agreed that each should proceed, with all the means at his disposal, to determine the initial point of said boundary on the Rio Grande, which the treaty stipulated to be at the parallel of 31° 47′ north latitude. It was further agreed that as soon as each party ascertained the precise point, both parties should compare notes and eliminate any differences or errors, by the methods best known to science, and conclude the final result, giving to each set of observations the weight due to them.

There being no other business before the commission, it adjourned, to meet when either commissioner should signify to the other that he had concluded the observations necessary to determine where the parallel of 31° 47′ north latitude intersects the Rio Grande.

W. H. EMORY.
JOSÉ SALAZAR Y LARREGUI.

RIO GRANDE, LATITUDE 31° 47′, *January* 10, 1855.

On the 9th of January, both commissioners having finished the observations necessary to determine the initial point of the boundary on the Rio Grande, met this day to compare results. The necessary measurements being made to connect the two observatories, and also the observatory established at Frontera in 1851–'52, it was ascertained that the difference between the determinations of the parallel of 31° 47′, made by the two commissions, was eighty-four hundredths of one second. It was then mutually agreed to take the mean between the two results; and the point thus ascertained was marked on the ground in presence of both commissioners, as the point where the parallel of 31° 47′ strikes the river; that is to say, the point where the boundary under the treaty of December 30, 1853, leaves the river to run westward.

The commission adjourned, to meet to-morrow at 10 o'clock a. m.

JOSÉ SALAZAR Y LARREGUI.
W. H. EMORY.

RIO GRANDE, LATITUDE 31° 47′, *January* 11, 1855.

The commission met and laid off the tangent to the parallel of 31° 47′, and having agreed upon the elements assumed for the figure of the earth, (Bessel's,) and compared the results of their computations for the length and azimuth of the ordinates connecting the tangent with the parallel, found them to correspond.

The commission adjourned, to meet to-morrow at 10 o'clock a. m.

JOSÉ SALAZAR Y LARREGUI.
W. H. EMORY.

PASO DEL NORTE, *January* 12, 1855.

The commission met agreeably to adjournment, and agreed to place one monument as near the river as the nature of the ground will admit, to be of dressed stone, having on the north face:

U. S.
BOUNDARY,
Under the treaty of December 30, 1853.

On the south face;

R. M.
Limite conforme al tratado de 30 de Diciembre de 1853.

On the west:

JOSE SALAZAR Y LARREGUI, *Comisionado Mexicano.*

On the east:

W. H. EMORY, *U. S. Commissioner.*

The commission further agreed:

1st. To erect a pyramid of rough stone, cemented with mortar, where the line strikes the crest of the first range of hills, and one of the same description in sight of the road leading from El Paso to the north.

2d. To put up a monument at the extremity of the line of 31° 47′ of the same kind, and with the same inscription, as that first named; to put up pyramids along the line wherever the facilities of water and stone will admit.

3d. To lay the foundation of the monument nearest the river on the 24th January.

There being no further business before the commission, it adjourned, to meet at 12 m. on the 24th instant.

W. H. EMORY.
JOSÉ SALAZAR Y LARREGUI.

PASO DEL NORTE, *January* 26, 1855.

The commission met on this day.

The Mexican commissioner having notified the American commissioner, by letter, on the 16th, that, in consequence of his absence in making a reconnoissance, he could not attend the placing of the corner-stone of the monument until the 31st, the American commissioner agreed with him to postpone the establishment of the foundation of the monument to that day at meridian, and we have this day met to give validity to that agreement. The American commissioner stated that, in consequence of not getting a sufficient supply of water immediately on the line, he had somewhat changed his plans, and had adopted, as the base of his operations, the north and south line between the parallels of 31° 47′ and 31° 20′. The first division of his party (the astronomical) had completed all their work here, and was ready to move on that line, escorted by the dragoons, and would so move to-morrow; that he, the commissioner, would follow with the balance of his party, the surveyors and the supplies, immediately after the completion of their joint labors on the 31st instant. He further stated, he had established points on the line beyond the road, and by the 31st his parties would have

progressed with the line as far on the Mesa as was convenient to operate from this side. He proposed to the Mexican commissioner to concur in these plans, and to start also westward. The Mexican commissioner stated he fully concurred in those plans and adopted them, but that in consequence of having no escort, he could not move at the time proposed, but would follow as soon as his escort arrived; the Mexican commissioner further stated, that whilst here he would take the charge of the three monuments, agreed upon at our meeting of the 12th to be erected at this end, and see them completed.

The American commissioner assented, and further stated that he would leave Jean Ball, the stone-mason, to assist in the work under the direction of the Mexican commissioner.

The American commissioner stated, that the treaty required, for the establishment of the line, the concurrence of the two commissioners; that when he establishes the points west in the absence of the Mexican commissioner, if any accident should prevent a subsequent visitation and verification of the points by the Mexican commissioner, the validity of the point might be questioned, and the work of himself, the American commissioner, achieved at great cost, might go for nothing.

The Mexican commissioner stated, in reply, that to avoid that difficulty, he would now adopt all those points which the American commissioner, in his absence, might establish, in his own name, on the line which the treaty stipulates.

JOSE SALAZAR Y LARREGUI.
W. H. EMORY.

INITIAL POINT ON THE RIO GRANDE, LAT. 31° 47′,
January 31, 1855.

The commission met, according to agreement, at meridian.

The chief officers of the vicinity, military and civil, from both sides of the line, being present, the foundation of the monument was laid. The following paper—one copy in English, the other in Spanish—was signed by the two commissioners and by the persons aforesaid, placed in a glass bottle, and deposited, at the depth of five feet, under the centre of the monument:

COPY OF THE PAPER.

"We, the undersigned, have this day assembled to witness the laying of the foundation of the monument which is to mark the initial point of the boundary between the United States and the Republic of Mexico, agreed upon, under the treaty of Mexico, on the part of the United States by William Hemsley Emory, and on the part of the Republic of Mexico by José Salazar y Larregui, latitude 31° 47′.

"W. H. EMORY, *U. S. Commissioner.*
"JOSÉ SALAZAR Y LARREGUI.
"C. RADZIMINSKI, *Sec'y U. S. B. C.*
"JOEL S. ANKRIM.
"E. B. ALEXANDER.
"CALEB SHERMAN.
"E. K. SMITH.
"JUAN JOSE SANCHEZ.
"ANTONIO ZEPEDA.
"GUADALUPE MIRANDA.
"VINCENTE AGUIRRE."

The American commissioner stated that he had already sent the whole of his astronomical force to the western end of the 100-mile line, and that it was his intention to follow in the coming week with the balance of his force.

The question of the time and place of the next meeting having been raised, the Mexican commissioner stated it was not in his power to say when he would be able to join the American commissioner, but that he would endeavor to do so as soon as possible.

The commission adjourned, to meet when the Mexican commissioner shall join the American commission.

JOSÉ SALAZAR Y LARREGUI.
W. H. EMORY.

FORT BLISS, *August* 14, 1855.

In pursuance of notification from the Mexican commissioner of his arrival, made in conformity with the last article agreed upon January 31, 1855, the commissioners met this day.

The United States commissioner stated that he had concluded the running and marking of the line up to the 111th meridian of longitude, at which point he met the United States and Mexican parties working eastward from the Colorado, and that in the unavoidable absence of the Mexican commissioner he had concluded an agreement with Señor Jimenez, first engineer of the Mexican commission, which he now presented to the Mexican commissioner, and asked his approval of the same.

The agreement is in the words following, to wit:

Señor Don Francisco Jimenez, first engineer of the boundary commission, on the part of Mexico, being duly empowered by the Mexican commissioner to run the line between the Colorado and the 111th meridian of longitude, having arrived at the camp of the American commissioner, the latter invited him, in the absence of the Mexican commissioner, to a conference, having for its object the more speedy completion of the unfinished portion of the line; and accordingly the two have met this day, and the following is the report of that conference and its results:

The American commissioner stated that he had separated from the Mexican commissioner on the 6th of February; that the Mexican commissioner being unable to proceed with the line at that time, had empowered the American commissioner to proceed with it, and had agreed to adopt the line established by him in conformity with the treaty.

The journal of the joint commission, duly signed and sealed, was exhibited to Señor Jimenez, and a copy of the record of the 26th January, duly authenticated, furnished him. The American commissioner stated that he had caused the line to be run and the monuments to be erected as far as the 111th meridian of longitude. That meridian had been established from observations at Los Nogales by principal assistant Clark; and Señor Jimenez was invited to inspect the instruments, still in position, with which these observations were made, the observations themselves, and the computations by which the results were obtained. The result of that inspection being satisfactory, the American commissioner proposed, that in view of the urgent demands of both governments, to complete the line, Señor Jimenez should unite with the American party, and direct the whole force of both parties to complete the tracing and marking of the line on the face of the earth from the 111th meridian, already established, to the point where Señor Jimenez and Lieutenant Michler left off in their attempt to run the line eastward.

Señor Jimenez assented to this proposition, and it was, therefore, agreed as follows:

That the plan of triangulation is impracticable; that the American and Mexican surveying party shall proceed forthwith to run the unfinished portion of the line; take the topography near the line; erect monuments at points where the line crosses a mine, a settlement, a road, or water.

It is agreed if either party break down, the other is not to suspend or delay operations in consequence of it.

It is agreed the Mexican party is to determine the latitude and longitude of some central point of the line as a check upon the tracing of the line, and the result is to be furnished the American commissioner, who agrees to accept that determination.

It is further agreed that the convention entered into between Señor Jimenez and Lieutenant Michler, April 26, and the additional article agreed upon May 1, 1855, are approved in all the articles not in conflict with this convention.

W. H. EMORY,
United States Commissioner.
FRANO. JIMENEZ,
First Engineer de la Como. de Limites Mexicano.

Los Nogales, *June* 21, 1855.

The Mexican commissioner having approved this step on the part of the first engineer of his commission, the United States commissioner gave a brief legend of operations up to the 111th meridian of longitude, and invited Mr. Salazar to inspect the notes, astronomical and geodetic, upon which the line was based, and the rough draughts of the maps made in the field.

The following is the substance of the legend:

After concluding all operations in the vicinity of the Rio Bravo, and pushing the line as far as was convenient, from that place, an astronomical station was established at Carrizalillo, which proved, from 72 observations with 46-inch zenith telescope, to be in latitude 31° 50′ 55″.23 north; and longitude 107° 56′ 03″.90, the result of observations during one lunation.

Carrizalillo was the nearest water to the terminal point of the 100-mile line near to parallel 31° 47′. A monument was established on the road due south of the observatory, and the parallel extended in both directions—east, until it met, in the sand-hills, the line produced from the Rio Bravo; west, it was extended to the end of the 100 miles, and the parallel was obtained by measuring ordinates from the tangent. The 100 miles was obtained by combining the observed longitude at Carrizalillo, and the distance actually measured.

From the end of the 100 miles a line was produced due south to meet the parallel of 31° 20′. The reconnoissance to find water at the junction of the meridian and 31° 20′ failed, and the observatory was established at the Espia, on the Rio Janos, ten or twelve miles east of the meridian. An elaborate set of observations (81) with zenith telescope, gave us the latitude of this observatory 31° 20′ 56″.45; the tangent of 31° 20′ was determined from this by direct measurements and produced to intersect meridian, and ordinates laid off to ascertain parallel. After producing parallel about seven miles, it was ascertained, as will be seen by the map, that the Ojo del Perro was near the line. The zenith telescope was reset, and a new tangent obtained; which result corresponding well with the last, this tangent was produced to the San Luis range of mountains. At the San Luis springs, about thirty miles west of the initial point of the parallel 31° 20′, a new observatory was erected, the latitude of which (31° 20′ 31″.51) was

ascertained by more than 97 observations. The tangent to the parallel 31° 20′ was ascertained and produced in both directions, east and west, and the ordinates to the curve of the parallel established. The coincidence between the new tangent and the old one, produced from Ojo del Perro, was satisfactory; after making the necessary allowance for the difference of ordinates, the error was found to be only a few feet. The tangent west was produced across the level of the San Luis valley and the Guadalupe Pass. In the mean time, a new observatory was erected at San Bernardino springs, and the latitude obtained with the same instrument, and nearly the same set of stars, was ascertained to be 31° 19′ 40″.38 by 57 observations. A third tangent was produced east and west, that east being found to correspond and verify the second tangent. This last tangent, being the third, was, on account of the absence of water, produced as far as the hills west of the San Pedro. While this was progressing, the astronomical party established itself to the north of Santa Cruz, on the river of the same name, and the latitude of the point was ascertained to be 31° 17′ 56″.33, from 73 observations. From this, a point on the parallel 31° 20′, due north, was ascertained by direct measurement, and a fourth tangent obtained, as in all the preceding cases, by elaborate measurements of the elongations of Polaris. An apprehension was entertained that the third tangent, by reason of its great prolongation, sometimes, as in passing the Guadalupe mountains, running over rough country, might prove crooked; but the verification by means of the fourth tangent was complete, showing the greatest probable error of either tangent, a distance of only 15 or 20 feet.

A chronometric reconnoissance was then made to the westward, and it was ascertained that the nearest durable water to the intersection of the meridian of 111 degrees west of Greenwich, and the parallel of 31° 20′, was at Los Nogales. At this point was established an observatory. The transit and zenith instruments were both mounted; and the result of 120 observations with the latter, and observations during two lunations with the first, gave for the latitude 31° 21′ 00″.48, and longitude 110° 51′ 02″.10 west of Greenwich. From observations at this observatory a fifth tangent was deduced, and extended by a separate party in both directions, running westward until the 111th meridian of longitude was reached. Owing to the difficulties of the country, the longitude was transferred by direct measurement and by triangulation.

Before this was concluded, a despatch was received giving the joint result of the Mexican and United States parties, of the latitude and longitude of the initial point on the Colorado river. With these data the azimuth of the line westward was computed to be 69° 19′ 45″.9, and laid off by measurements from the elongation of Polaris.

This left nothing to be done but to trace the line and complete the topography between the 111th and the Colorado, and the dispositions made for that are all embraced in the convention between Senor Jimenez and myself, and Señor Jimenez and Lieutenant Michler, to which your approval has been given.

Major Emory, the American commissioner, further stated, that in reference to the instruments used, and the methods employed in obtaining results, Mr. Salazar, the Mexican commissioner, from long experience, was familiar with the mode adopted by both commissions, and it was therefore not necessary to enter into particulars—the notes would show for themselves; but he begged to remind Mr. Salazar that they had discussed before, the subject of longitude, and it was agreed between them, that in all determinations of longitude by the moon and moon-culminating stars they should take the Greenwich ephemeris, and not await the publication of the corresponding observations made at Greenwich, as at this distance it would necessarily involve a delay of eighteen months or two years—a result clearly not contemplated

by either government. The correction due from corresponding observations cannot be foretold, but is small, and as likely to be to the advantage of one as the other.

The monuments erected on the line were of two classes—first, of dressed stone, laid without mortar; second, of round stones undressed, forming simply mounds.

Of the first, one was erected at the point south of the Carrizalillo; another at the intersection of meridian 108° 09′ 41″.85 and parallel 31° 20′; one at San Luis springs; two at San Bernardino; one at San Pedro; one north of Santa Cruz; one where the line crosses (second time) Santa Cruz river; one at Los Nogales; and one at intersection of 111° and 31° 20′. Many mounds of the second class were erected, always at points where the line crosses a road or trail. Mr. Salazar stated that he had erected, of dressed stone, in a permanent and durable manner, a monument at the initial point on the Rio Bravo, and two monuments west of that point.

To give the Mexican commissioner time to make a thorough and critical examination of the data upon which the determinations are based, and to inspect the maps and take copies of such portions of them as he might desire, they were placed in his hands, and the commission adjourned, to meet in El Paso at 10 o'clock on the 16th.

W. H. EMORY, *U. S. Comm'r.*
JOSÉ SALAZAR Y LARREGUI, *Com'o Mex'o.*

EL PASO, *August* 16, 1855.

The commission met, agreeably to adjournment.

Mr. Salazar, the Mexican commissioner, stated he had fully examined all the documents, observations, notes, and maps, and the result of his examination was an entire conviction that the line had been run correctly throughout, including those parts during the running of which he was necessarily absent. But since the subject had been called to his notice by Mr. Emory, the U. S. commissioner, to the effect that, in consequence of the absence of water at the time, only a mound had been established at the junction of the meridian and parallel of 31° 47′, he thought, now that the rainy season had commenced, and water was everywhere to be found, a monument of dressed stone should be erected at that point; and he stated he would himself undertake to place it at that point. He stated, also, in consequence of the absence of water he had not been able to place a monument, as he had intended to do, to the south of the Potrillo mountains, on the parallel of 31° 47′, and that he would do both at the same time.

Mr. Emory, the American commissioner, stated his assent to this proposition, and further stated, that although he believed he had erected monuments or mounds along the whole line wherever the line crossed or passed near permanent water, a road, a mine, or town, or, in fact, any habitable point, yet he desired Mr. Salazar, if, in the course of his visitation of those parts of the line not before examined by him he should see any point omitted where a monument should be placed or substituted for a mound, not to hesitate to do so.

Mr. Emory said he would now state what he had informally stated before, that he had directed Lieut. Michler to send him an express to San Antonio the moment Señor Jimenez and himself finished the topography of the line between the 111th meridian and the Colorado.

The examination of the notes, maps, &c., being completed, and all discussion of the different subjects connected with the line being closed, the results of the foregoing conferences were embodied in the following articles of agreement:

1. Mr. Emory, the American commissioner, agrees to adopt, unconditionally, all monuments, mounds, lines, and points now established by Mr. Salazar, the Mexican commissioner, and by Don Francisco Jimenez, first engineer of the Mexican commission.

2. Mr. Salazar, the Mexican commissioner, agrees to adopt unconditionally all the monuments, mounds, lines, and points now established by Mr. Emory, the American commissioner, and by his assistants, reserving the right to substitute a monument for a mound at the intersection of the meridian with the parallel of 31° 47′, and to erect a mound or monument on the same parallel to the south of the Potrillo, and at any point along the line already established where it may appear to him necessary, and where heretofore it was impracticable, owing to the absence of water.

3. The two commissioners agree to declare, and do declare, the line surveyed, marked, and established as far as the 111th meridian of longitude, as the true line of boundary between the two republics, and they agree also to declare, and do declare, the line established from the 111th to its intersection with the Colorado, the true line between the two republics. They further agree to declare the line fully surveyed, marked, and established through its whole extent as soon as notification is received from Señor Jimenez and Lieutenant Michler that the topography of the last named line is completed between the 111th meridian and the Colorado river, and it shall be the duty of each to inform the other when such notification is received, and also to report to their respective governments that all the field-work of the boundary is concluded.

4. To carry out the stipulations in the first article of the treaty of December 30th, 1853, requiring the commissioners to make proper plans of their operations. It is agreed that the two commissioners, with their assistants, shall meet in the city of Washington on the first day of April, 1856.

W. H. EMORY, *U. S. Commissioner.*
JOSÉ SALAZAR Y LARREGUI, *Comm'o Mex'a.*

There being no further business before the commission, it adjourned, to meet in Washington, April 1, 1856.

W. H. EMORY, *U. S. Commissioner.*
JOSÉ SALAZAR Y LARREGUI, *Comm'o Mex'a.*

AGREEMENT BETWEEN LIEUTENANT MICHLER AND SEÑOR JIMENEZ, REFERRED TO AT THE MEETING OF THE JOINT COMMISSION, AUGUST 14, MADE AT CAMP NEAR THE INITIAL POINT ON THE RIO COLORADO, ON THE TWENTY-SIXTH OF APRIL, 1855.

According to article first of the treaty of December 30, 1853, between the republics of the United States and Mexico, we, the undersigned, duly authorized to fix the initial point on the Rio Colorado, twenty English miles below the junction of this river with the Gila, and to trace and mark the line from this point to the intersection of the parallel of 31° 20′ north latitude, with the 111th meridian of longitude west from Greenwich—all the operations necessary to determine this point and the direction of the line having been completed—agree as follows:

1. That the latitude of said initial point, by a mean of the results obtained by each party, is 32° 29′ 44″.45 north, and that the longitude is 114° 48′ 44″.53 west from Greenwich, determined from a triangulation by N. Michler, lieutenant Topographical Engineers, United States army, who has transferred the position of the monument on the old boundary line near the junc-

tion to the new initial point. This longitude has been adopted by Mr. Francisco Jimenez, first engineer Mexican boundary commission, although he proposed to refer it by flashes between the two points.*

2. That with the above data the computed azimuth of the line running eastward is found to be 71° 20′ 43″.8 southeast at the initial point, and 69° 19′ 45″.9 northwest at the end of the line, and the distance between the two points is 382,844.87 metres, equal to 237.63565 English miles. Having commenced to trace said line on the bank of the river, distant from the initial point 964.62 metres, equal to 3,164.84 English feet, the azimuth at this point, newly computed, was found to be 71° 20′ 25″ southeast.

3. That the line be traced by both parties at the same time, each alternating with the other at the successive stations; that the distance of the line be measured by triangulation, one party operating from the initial point to the environs of Sonoyta, the other thence to the termination of the line; and that the results be mutually exchanged.

4. That at all prominent points of the line which are deemed proper, suitable monuments, from such materials as are at hand, be erected to mark it.

5. That the point where the line has commenced to be traced be called by the Roman number (1;) that all succeeding stations shall be in the order (II,) (III,) (IV,) &c., &c.

6. That as it is impossible to place a permanent monument at the starting point (I) of the line, an iron monument has been placed at station (II) in the direction of the line, and distant from station (I) 3171.12 metres, equal to 10404.12 English feet; computed latitude of said monument, 32° 29′ 01″.48 north, and longitude 114° 46′ 14″.43 west of Greenwich.

7. That the above be submitted to the consideration of the commissioners of the respective countries for their approval.

N. MICHLER, *Lieut. Topl. Engrs. U. S. A.,*
U. S. Boundary Commission.

FRANCISCO JIMENEZ,
1st Ingo. de la Com. del Limite Mex'o.

After having signed the above agreement the tracing of the line was continued, in accordance with the same, from station II to station III, a distance of 829.81 metres. From station III a party was sent to a point of the mountain range, about twenty-five miles distant, to endeavor to establish station IV. This party having made a reconnoissance of the country for the purpose of finding water, was unsuccessful in discovering sufficient for the wants of even the small number of men necessary to execute the work; the nature of the country forbid the practicability of furnishing by any means of transportation what was deemed necessary, as it is a continuous desert of heavy sand, entirely destitute of vegetation. A party previously sent to reconnoitre the country for water also brought the intelligence that not a drop was to be had from the Colorado to Quitobaquita, a distance of one hundred and twenty-five miles in the direction of the line. In consequence, therefore, of the utter impracticability of prosecuting the work from the west end of the line, we, the undersigned, on this the first day of May, 1855, agree to add the following article to the above agreement:

8. That both parties cease operations at the west end and proceed to the east end of the line, by the road along the Gila, the only one available at this season of the year, there to fix the

* NOTE.—Captain Jimenez subsequently caused the monument on the old boundary, and the new initial point on the Colorado, to be connected by triangulation, and obtained the same result as Lieutenant Michler.

point of intersection of the parallel of 31° 20′ north latitude with the 111th meridian west of Greenwich, and afterwards to proceed to trace the line from that point westward as far as practicable.

N. MICHLER, *Lieut. Topl. Engrs. U. S. A.*,
U. S. Boundary Commission.
FRANCISCO JIMENEZ,
1st Ingo. de la Com: del Limite Mex'o.

WASHINGTON, *December* 18, 1855.

SIR: I communicated to you, a few days ago, a telegraphic despatch reporting the completion of the survey of the boundary.

I have now the honor to inform you that I have received official information of the arrival of the last surveying party of the commission in San Antonio, and the completion of the work assigned to it.

I have also to communicate to you the copy of a letter from Señor Salazar, the Mexican commissioner, informing me of the complete fulfilment of the 3d article of the convention with him, signed August 16.

The field-work of the boundary commission is therefore at an end.

I have the honor to be, your obedient servant,

W. H. EMORY, *U. S. Commissioner.*

Hon. ROBERT MCCLELLAND, *Secretary of the Interior.*

[Translation.]

JANOS, *October* 15, 1855.

SIR: Lieut. Michler has just delivered to me, personally, an official note, whereby I am informed that the survey of the line between the meridian of 111° and the Colorado has been completed.

This I have communicated to my government; and I advise you of the same, hoping that you will be pleased to communicate it to that of the United States, conformably to the resolution of article 3d of the convention held on the 16th of August of the present year.

I have the pleasure again to subscribe myself, with the greatest respect, your obedient servant,

JOSÉ SALAZAR Y LARREGUI,
Mexican Commissioner, &c., &c.

Col. W. H. EMORY,
United States Commissioner.

[Translation of official document sent by Mr. Salazar to the government of Mexico.]

EXCELLENT SIR: With my note under date of the 20th August, I enclosed to you copies of the last meeting held by the commissioner of the United States and myself on the 14th, 16th, and 20th of that month. By the 3d article of the agreement of the 16th, your excellency will have seen that we agreed on declaring, and do declare, in effect, that the line was completely *surveyed*, *marked*, and *fixed* in all its length, so soon as notice was received from Señor Jimenez and Lieut. Michler that the topography of the last-mentioned line had been completed between

the 111th meridian and the Colorado; and the same 3d article imposes upon us the mutual obligation to advise each other, and our respective governments, that all the field-work of the line was concluded.

In complying with the 3d article of this convention, celebrated on the 16th August, between the American commissioner (Major W. H. Emory) and myself, I now notify your excellency that the topography of the line between the 111th meridian and the Colorado is now complete, by the acknowledgment of Messrs. Jimenez and Lieut. Michler, as your excellency will see by the original letter, which is herewith enclosed, and which was handed to me in person by Lieut. Michler, who to-day takes his departure for the United States; and Lieut. Michler also informed me that Señor Jimenez had started on the 1st instant for the city of Mexico, after they had, together, concluded and officially agreed upon the line which had been placed under their charge.

All the work, therefore, necessary for the surveying, marking, and establishing of the boundary line between Mexico and the United States, in conformity with the treaty of the 30th of December, 1853, is now terminated.

In carrying out still further the requirements of the said 3d article of the convention with the commissioner of the United States, I have to-day written him as follows:

"JANOS, *October* 15, 1855.

"SIR: Lieut. Michler has just handed to me, in person, an official note, by which I am informed that the topography of the line between the meridian 111° and the Colorado is completed, the which I have communicated to my government; and I advise you of the same, trusting that you will also communicate the fact to the United States, in conformity with the 3d article of the convention made between us the 16th August.

"With great respect, I have the honor to be, &c.,

"JOSÉ SALAZAR Y LARREGUI.

"Sr. Don W. H. EMORY,

"*Commissioner of the United States.*"

And now, most excellent sir, the treaty indicates who should declare surveyed, marked, and established (or fixed) the boundary line, and gives to the commissioners ample powers; and thus no doubt can exist that the commissioners, and not the governments, can, and must, make this declaration. This was accordingly done by Major Emory and myself, as such commissioners, by our convention on the 16th of August, as shown by its terms, with the sole condition that it shall be valid whenever either of us received the advice which I have just communicated to your excellency and to the American commissioner. It now only remains for the government of the United States to fulfil its part of the obligations imposed by the 3d article of the treaty.

God and liberty. Janos, October 15, 1855.

JOSÉ SALAZAR Y LARREGUI.

His Excellency the MINISTER OF FOREIGN RELATIONS, *Mexico.*

WASHINGTON CITY, *June* 24, 1856.

In pursuance of previous adjournment, the two commissioners met this day at the office of the joint commission. Señor Salazar stated that after he separated from Mr. Emory on the 20th August, 1855, he reviewed with his parties the different lines of the boundary; that is to say, the parallel 31° 47′, the meridian, and the parallel 31° 20′, on which lines the Mexican commission executed the following work:

From the point south of El Carrizalillo, on which was erected a monument, he observed minutely on Polaris to determine the prime vertical on both sides, east and west. The prime vertical and the parallel 31° 47′ were connected by a triangulation—on the east side with that which had been made at the initial point, and on the west side with the intersection of meridian. By this triangulation five points to the east were fixed, at which points he caused to be erected monuments of stone, with mortar, because he found not one established by the United States commission in said direction.

The monument at the road was reconstructed of stone, with mortar. Upon all of them was inscribed the abridged inscription agreed upon. This line was then marked with ten monuments. That at the west end he caused to be erected of dressed stone with mortar, and inscribed with the complete inscription agreed upon, similar to that which was erected at the initial point on the Rio Bravo.

Mr. Salazar stated that he observed at the south end of the meridian for latitude and longitude, his results differing very little from those of the United States commission; that from this point was carried north a triangulation which was connected at the north end with that made on the parallel 31° 47′, and was used to determine the position of said end on the parallel and on the meridian; that these two extreme points were left where the United States commission established them; that having found no monument between them, he caused one to be erected intermediate, in sight of the Ojo de los Mosquitos, of dressed stone laid in mortar, with the usual inscriptions; that the monument at the south end was erected of dressed stone and mortar with inscriptions similar in all respects to those at the north end and at the initial point. On the parallel 31° 20′, besides the observations he made at the intersection, he observed for latitude at San Luis springs, at San Bernardino, and San Pedro river; he found monuments at the two first named points, but none at the last; that his observations proved that the points were on the parallel 31° 20′, and he caused monuments to be erected at these points with mortar, having the usual inscriptions upon them, and that he thought it proper to erect a monument of the same kind in Guadalupe Pass.

Mr. Emory stated his entire satisfaction with what had been done by Mr. Salazar, and gave his assent thereto, except with regard to the monument at San Pedro river. He desired to call in Mr. Weyss, who was with Mr. Von Hippel when the monument was erected on the San Pedro. His own recollection was, that a very substantial monument had been erected at the San Pedro by the United States commission.

Mr. Weyss was brought before the commissioners, and stated that a monument of dressed stone, with the usual inscription, was erected on the parallel 31° 20′, three thousand eight hundred and twenty-five feet west of the San Pedro river. The maps and views were exhibited showing the exact locality of this monument. Mr. Emory stated, if the Indians had destroyed that monument it was all very well; but if it was still standing, there might be some discrepancy, amounting, possibly, to 1″ of arc, or one hundred feet between the latitude of the monu-

ment erected by Mr. Salazar and that erected under his orders. If so, it might hereafter, when the country was settled, produce confusion.

Mr. Salazar stated, that in case both existed he would take the monument erected by Mr. Von Hippel as the true boundary. Assented to by Major Emory.

The commission then adjourned, to meet at 9^h 30^m to-morrow morning.

WASHINGTON CITY, *June* 25, 1856.

Commission met at 9^h 30^m a. m., and the following preamble and resolution were adopted:

Whereas Señor Salazar has stated it to be within his personal knowledge that some of the monuments erected by Mr. Emory were destroyed and others mutilated by the Indians, in the short space of time elapsing between the construction of these monuments and the final inspection of them by Mr. Salazar; and whereas it appears, from the maps and views which have been drawn, that the topographical features of the country, based upon astronomical determinations, are represented in sufficient detail to enable any intelligent person to identify the line at any required point; therefore, be it

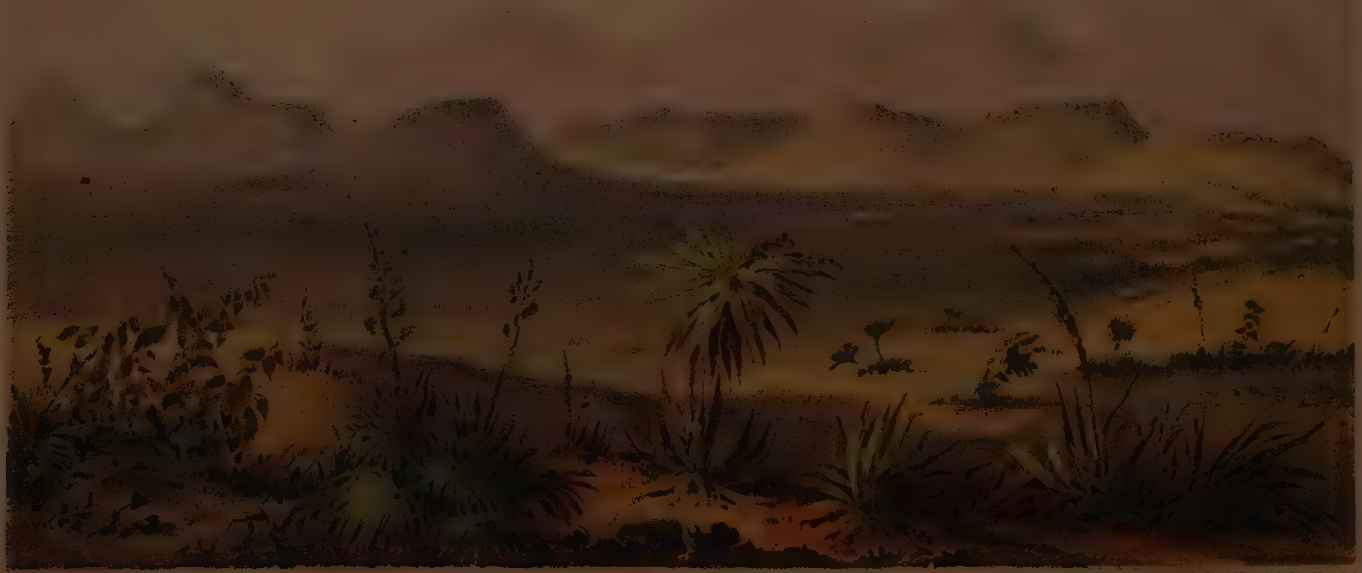
Resolved, and agreed upon in joint commission, that these maps and views, duplicate copies of which will be made—one to be deposited with the United States, the other with the Mexican government—shall be the evidence of the location of the true line, and shall be the record to which all disputes between the inhabitants on either side of the line, as to the location of that line, shall be referred; and it is further agreed that the line shown by these maps and views shall be regarded as the true line, from which there shall be no appeal or departure.

Mr. Salazar proposed, with the view of carrying out the labors to the end in the soonest time, that the detailed maps be made, one copy by each commission, on a scale of $\frac{1}{60000}$, and a general map of the whole boundary on a scale of $\frac{1}{600000}$. That at the end, when the total work was done, the maps should be signed, to be given to the respective governments, and the two commissions should exchange the topographical and astronomical data by which each commission has arrived at its results in the field.

Mr. Emory stated that he had constructed the maps of the country from San Diego to the Colorado on the scale of $\frac{1}{30000}$; the projections for the maps of all the other portion were on a scale of $\frac{1}{60000}$. It would be exceedingly inconvenient, if not impracticable, to reconstruct them; he therefore proposed that Mr. Salazar's proposition should be so far modified as to leave the California section of the work to stand as it is, on a scale of $\frac{1}{30000}$. This was assented to by Mr. Salazar, and it was agreed as follows, viz:

That the detailed maps of the California section of the work shall be received on a scale of $\frac{1}{30000}$, the detailed maps for all the other portion of the boundary shall be completed on a scale of $\frac{1}{60000}$, and that a general map of the boundary shall be constructed on a scale of $\frac{1}{600000}$, which maps, when completed, shall form the evidence of the true line referred to in the agreement made this day.

W. H. EMORY.
JOSÉ SALAZAR Y LARREGUI.



Lith of SARONY MAJOR & KNAPP, New York.

PRAIRIE OF THE ANTELOPE.

CHAPTER III.

GENERAL DESCRIPTION OF THE COUNTRY.

SUITABLENESS AS A BOUNDARY.—GREAT PLATEAU OF AMERICA AND MOUNTAIN RANGES.—DEPRESSION OF MOUNTAINS NEAR THE PARALLEL OF THIRTY-TWO DEGREES NORTH LATITUDE.—GEOGRAPHICAL ERRORS.—METALLIFEROUS REGIONS.—LAKES.—SAND DESERTS.—VEGETATION AND AGRICULTURAL CAPACITY.—CHARACTER OF THE RIO BRAVO.—RAILWAY.—ASTRONOMICAL DETERMINATIONS.

The boundary between the United States and Mexico, extends entirely across the continent from ocean to ocean. That portion of it which is formed by the Rio Bravo, below the mouth of the San Pedro, or Devil's river of Texas, makes a boundary, which, in the absence of extradition laws, must always be a source of controversy between the United States and Mexico.

In other respects, the boundary is a good one; and if the United States is determined to resist what appears to me the inevitable expansive force of her institutions and people, and set limits to her territory before reaching the Isthmus of Darien, no line traversing the continent could probably be found which is better suited to the purpose.

In this respect it is fortunate that two nations, which differ so much in laws, religion, customs, and physical wants, should be separated by lines, marking great features in physical geography.

The boundary is embraced in the zone separating the tropical from the temperate and more northern regions. Here, waters unite, some of which are furnished by the melting of northern snows, whilst those from the south are supplied from mountains watered by the tropical rains. To the north of this zone, the showers from the tropics cease to refresh the earth, and within it, all the flora and fauna which characterize the northern and temperate regions almost disappear, and are not entirely supplanted by those of the tropics.

It is indeed a neutral region, having peculiar characteristics, so different as to stamp upon vegetable and animal life features of its own.

The most remarkable and apparent difference between this region and those of the States of the Union generally, and that which, perhaps, creates, as much as any other one cause, the difference in its botanical and zoological productions, is the hygrometric state of the atmosphere; for, while the plants and animals assume new forms in life, the crust of the earth, the soil, and the rocks, are everywhere familiar, and have many types, indeed fac similes, over the rest of the American continent.

It is very arid; but this is also the character of all the country north of the tropics, and west of the 100th meridian of longitude, until you reach the last slope to the Pacific—a narrow belt, seldom exceeding 200 miles in width, and sometimes not more than ten. The zone extending from the Gulf of Mexico to the Pacific, embracing the boundary, contains a large proportion of arid lands; yet this dry region is, perhaps, narrower on the line of boundary than on any portion of the continent north of it, within the limits of the United States, and is occasionally refreshed by showers in the summer season, and so far presents an advantage over the arid belt to the north.

A general description of the topographical features of the country along the boundary between the United States and Mexico, (traversing the whole breadth of the continent,) cannot be made comprehensive, without presenting in the same view the great outline of the continent itself.

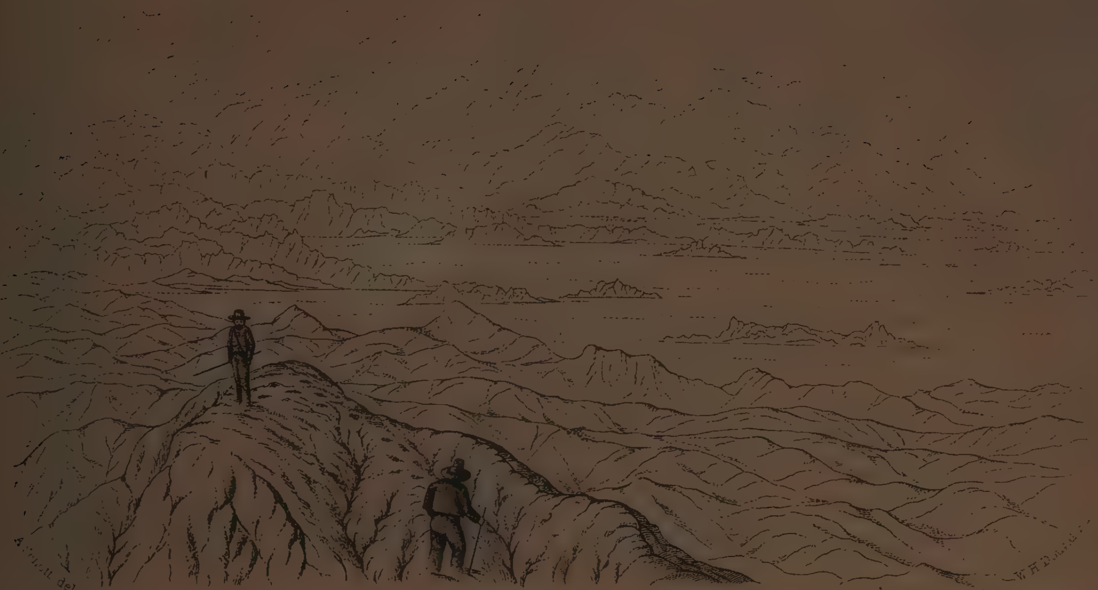
It is now well known that the most extensive feature in the continent is the plateau, or table-land, which traverses this country from the unexplored region of the north to its southernmost extremity, varying in width from five miles to one thousand, attaining its greatest elevation in the Andes of South America, its least elevation and breadth on the Isthmus of Panama and in Central America, and its greatest breadth about the parallel of 38° north latitude. On the northern portion of the continent, this plateau attains its greatest height in Mexico, where it is ten thousand feet above the level of the sea. Its lowest depression is along the line of boundary, about the parallel of 32° north latitude, where it is about four thousand feet above the sea. Thence it ascends again, and preserves an elevation varying from seven to eight thousand feet, to near the 49th parallel, where it is again depressed. This plateau, both in North and South America, occupies the western side of the continent and is traversed by ranges of mountains, the highest peak of which, in North America, is Mount Elias, 17,000 feet above the sea, and in South America is Mount Aconcagua, 21,500 feet above the sea. The climatic features in this plateau, within the United States, are excessive dryness and great changes of temperature between night and day, often as much as 65°.

The principal ranges of these mountains in North America, naming them in the order of their proximity to the coast of the Pacific ocean, are, first, the Cordilleras of California and Oregon, or the Coast Range of mountains; second, the Sierra Nevada, (which, as its name denotes, is a ridge of mountains and craggy rocks, covered with snow;) third, the Sierra Madre, another range of mountains, which was supposed to separate the waters flowing into the two oceans; and, fourth, the Rocky mountains.

The idea conveyed by the name Sierra Madre is very generally adopted by the Mexicans, yet I doubt very much if any continuous ridge or chain of mountains can be found which separates the waters flowing into the Pacific from those flowing into the Atlantic. I am also quite well satisfied that the mountains known as Sierra Madre, in New Mexico, are not the same range as those known by that name in Chihuahua and Sonora, and that both are distinct from the range west and south of Monterey of the same name; but the Coast Range, the Sierra Nevada, and the Rocky mountains, preserve a very considerable continuity throughout the limits of the United States. The Coast Range follows the generally northwest direction of the beach of the Pacific coast, and, for a very considerable distance, rises abruptly from the sea. Along the whole coast it is in view of the navigator, presenting an imposing and ever-changing panorama. It may be said to terminate at Cape San Lucas, the southern extremity of Lower California.

It is the slope towards the sea of this range of mountains which forms the western border of the arid region, and is, in my judgment, the only continuous agricultural country west of the 100th meridian. There are many detached valleys and basins affording facilities for irrigation, where the cereals, the vine, and all the plants which conduce to the comfort of man, are produced luxuriantly; but they form the exception rather than the general rule, and are separated by arid plains or mountains.

The Sierra Nevada, the Cascade Range, and the Rocky mountains, preserve a general parallelism to each other and to that of the Coast Range. Commencing at the north, they can be traced continuously until we reach to within a few degrees of latitude of the region



VIEW TOWARDS THE EASTERN SLOPE OF THE CALIFORNIAN CORDILLERAS TAKEN FROM NEAR CARRIZO CREEK

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UPHEAVINGS BORDERING THE COLORADO DESERT ON THE FOOT OF THE CALIFORNIAN CORDILLERAS
TAKEN FROM CARRIZO CREEK–LOOKING SOUTH EAST

of the boundary, where occurs, in all the ranges except the Coast Range, the remarkable depression in the continent, or rather absence in the continuity of the ranges of mountains, hereafter to be described.

The Sierra Nevada, in latitude 33° N., branches; one great division unites with the Coast Range, forming the elevated promontory of Lower California, and presenting, when figured on the map, the appearance of the letter Y, (Tulare valley resting in the fork of the letter;) other branches or spurs are thrown off in a southeast direction, crossing the Gila at the mouth, and many miles above, and traversing the newly-acquired territory in the meridian of Santa Cruz and Tucson.

That range, as well as the Sierra Madre and the Rocky mountains, about the parallel of 32°, lose their continuous character, and assume the forms that are graphically described in the western country as *lost* mountains—that is to say, mountains which have no apparent connexion with each other. They preserve, however, their general direction N. W. and S. E., showing that the upheaving power which produced them was the same, but in diminished and irregular force. They rise abruptly from the plateau, and disappear as suddenly, and, by winding around the bases of these mountains, it is possible to pass through the mountain system, in this region, near the parallel of 32°, almost on the level of the plateau; so that if the sea were to rise 4,000 feet above its present level, the navigator could cross the continent near the 32d parallel of latitude. He would be on soundings of uniform depth, from the Gulf of California to the Pecos river. He would see to the north and to the south prominent peaks and sierras, and at times his passage would be narrow and intricate. At El Paso he would be within gun-shot of both shores.

I noticed this remarkable depression in the continent, in an exploration made by me in 1846, and called to it the attention of Mr. Buchanan, then Secretary of State; and it was upon this information that he instructed our minister, then negotiating the treaty of Guadalupe Hidalgo, not to take a line north of the 32d parallel of latitude, in the boundary between the United States and Mexico.

Passing to the south of this parallel, in about that of 31°, we find the plateau rising rapidly to the table-lands of Mexico, the ranges above described are no longer traceable, and the plateau gives evidence of having been disturbed by tremendous plutonic forces, and the mountains assume a loftier and more rugged and diversified appearance. As I have said before, the Sierra Madre range of mountains cannot be traced distinctly with our present information.

The Rocky mountains, near the head-waters of the Rio Bravo, throw off spurs, which add to the confusion and make it difficult to separate the range from that called in New Mexico the Sierra Madre.

It may be a question whether the Rocky mountain range is not divided by the Rio Bravo; and if so, that which I have designated as the Sierra Madre of New Mexico will, in that case, become a spur of the Rocky mountains. The geological formations to which I shall presently refer, seem to favor this hypothesis. If this hypothesis be true, the Sierra Madre of New Mexico and the Rocky mountain system are the same, and are only divided by the Rio Bravo. But this is a question which does not affect the general topographical description of the country, and may be disregarded here. What I have described refers more particularly to the country west of the Rio Bravo.

The Rocky mountain system, commencing in the north, beyond the source of this river, and beyond the limits of the 49th degree of north latitude, is the distinguishing feature of the

country east of that river until we reach the great plains lying between the base of those mountains and the valley of the Mississippi. The axis of maximum elevation preserves a general parallelism to the Sierra Nevada range. Its principal chain, after passing the 36th parallel of latitude, becomes less elevated, and finally terminates in the Organ mountains near El Paso, re-appearing again to the south and east, and becoming at last merged in the great mountain masses in Mexico.

Another branch of these mountains diverges about the head of the Pecos, and running south with unequal elevation, crosses the Rio Bravo between the 102d and 106th meridian of longitude, forming the great bend in that river, and producing one of the most remarkable features on the face of the globe—that of a river traversing at an oblique angle a chain of lofty mountains, and making through these on a gigantic scale, what is called in Spanish America a cañon—that is, a river hemmed in by vertical walls.

Entrance to Cañon of Sierra Carmel, Rio Bravo del Norte.

These mountains to the south of the river expand in width and height, attaining a great elevation in the neighborhood of Monterey, Saltillo, and Buena Vista, and forming one side of the Bolson Mapimi, and it is my impression that these mountains are identical with what is called in Nuevo Leon the Sierra Madre.

A third, but subordinate range, branches from the main chain about the same parallel as that last described, and terminates in the Llano Estacado or the Staked Plains, from which issue the Red river and other rivers of Texas. From the foot of the Llano Estacado the country falls, sometimes by steps, but most generally by gentle slopes, to the shores of the Gulf of Mexico, the crust only broken by the washing of water, and in a few places by the protrusion of igneous rocks. The view of the bed of Devil's river will give a very good idea of the manner in which the general level of the surface forming this great cretaceous plane is broken by the action of water.

RIO SAN PEDRO — ABOVE SECOND CROSSING

The igneous protrusions which occur are composed of greenstone or basalt, and are traced from the San Saba mountain, by the head of the Leona, to Santa Rosa, in Mexico, where it unites with the main ridge, at an angle of about forty-five degrees. The point where they unite is rich in silver mines. At Santa Rosa the Spaniards had sunk extensive shafts and made a tunnel a mile and a half in length, which was not completed when the revolution of 1825 broke out; since then all extensive operations have been suspended, and the country, rich in minerals and in the production of the cereals and of tropical plants, has been a prey to the incursions of banditti and Indians, and at this time Wild Cat and his band of Florida Indians are settled near there, to add to the disorder and misrule of this beautiful region.

It has been observed that these metalliferous rocks generally occur at the junction of two systems, or where some unusual disturbance or change in the geological structure takes place. Hence we may expect to find these silver-bearing rocks along the boundary line, where the upheaving force, after subsiding near the bed of the Gila river, begins again to re-appear to the south.

The remaining mountain feature of North America, the Appalachian, is referred to here, only to illustrate by comparison the mountain system of the western part of the continent. That chain, grand as it is, sinks into insignificance when compared to those I have attempted to describe. It is nearly at right-angles to the western chain of mountains, is less elevated, and sheds its waters, as is well known, clear on both sides; on the one side into the Atlantic, and on the other side into the Mississippi and the Gulf of Mexico. On both sides, the slopes are comparatively gentle, and the soil fertile, and, refreshed by frequent showers, yields in abundance all that contributes to the wants of man; on the western side of this slope, between it and the desert border of the Rocky mountains, such an expanse of fertile country exists as can be found, in one body, nowhere else on the face of the globe, producing all the fruits of the earth, including those found in every zone, from the boreal regions to the tropics. Persons familiar with its character, as most who read this memoir are, will scarcely be able to comprehend, still less to believe, the character given to the more western and less favored regions described in this report.

In the fanciful and exaggerated description given by many of the character of the western half of the continent, some have no doubt been influenced by a desire to favor particular routes of travel for the emigrants to follow; others by a desire to commend themselves to the political favor of those interested in the settlement and sale of the lands; but much the greater portion by estimating the soil alone, which is generally good, without giving due weight to the infrequency of rains, or the absence of the necessary humidity in the atmosphere to produce a profitable vegetation. But be the motive what it may, the influence has been equally unfortunate by directing legislation and the military occupation of the country, as if it were susceptible of continuous settlement, from the peaks of the Alleghanies to the shores of the Pacific.

Between the two most distinctly-marked ranges of mountains, before described, (the Rocky mountains and the Sierra Nevada,) a succession of minor ranges occur, some of which are many hundred miles in extent, while others appear like isolated mountains, rising above the general level of the plateau. Most of them preserve a general system of parallelism; others present their lines of maximum elevation, forming very considerable angles with the general direction, and all, when traced upon a map, exhibit lines varying from right lines to every degree of curvature.

The whole system, plateau and mountain, seems to have been produced by a succession of forces analogous to each other in direction, but differing in intensity and occurring at long intervals. The prevalence of granite and other unstratified rocks throughout the Sierra Nevada suggests the probability of its being the oldest of the western range of mountains. The identity of its rocks, generally, with those of the Alleghany mountains, marks these two distinct and detached chains as probably contemporaneous. The rocks marking these mountains are of the description commonly traversed by gold and copper veins, as is the case in Oregon, California, Virginia, and North Carolina. Travelling eastward from the Pacific along the bed of the Gila, we encountered similar rocks in a chain of mountains as far east as the Pimo village. This chain, characterized also by the presence of gneiss, mica, and talcose slate, has been traced as far south as the present boundary, where it crosses the Santa Cruz river, between longitude 110 and 111; and in that neighborhood we saw everywhere the remains of gold mines, from which the operators had been driven by the Apaches.

Pursuing our course eastward along the boundary from the meridian of 110°, we cross the San Pedro, the Guadalupe, and the San Luis range of mountains in the order in which they are named, the middle range being chiefly characterized by sienitic aggregates, granitic lava, and immense masses of conglomerate, or breccia. Precisely the same formation is found in the cañon of the Gila, some distance to the north, about the meridian of what is called, in my reconnoissance of 1846, Disappointment creek. And no doubt, when future surveys shall develop a more minute knowledge of the physical geography of the country, each of these ranges of mountains will find its equivalent to the north and to the south. With the present information, I shall not even attempt to connect them conjecturally.

Hypothetical geography has proceeded far enough in the United States. In no country has it been carried to such an extent, or been attended with more diastrous consequences. This pernicious system was commenced under the eminent auspices of Baron Humboldt, who, from a few excursions into Mexico, attempted to figure the whole North American continent. It has been followed by individuals to carry out objects of their own. In this way it has come to pass, that, with no other evidence than that furnished by a party of persons travelling on muleback, at the top of their speed, across the continent, the opinion of the country has been held in suspense upon the subject of the proper route for a railway, and even a preference created in the public mind in favor of a route which actual survey has demonstrated to be the most impracticable of all the routes between the 49th and 32d parallels of latitude. On the same kind of unsubstantial information maps of the whole continent have been produced and engraved in the highest style of art, and sent forth to receive the patronage of Congress, and the applause of geographical societies at home and abroad, while the substantial contributors to accurate geography have seen their works pilfered and distorted, and themselves overlooked and forgotten.

The San Luis mountains, a distant view of which is given from the Alamo Hueco springs looking west, rise abruptly from the plains about three leagues north of the parallel 31°.20, and, as they run south, assume by far the most formidable appearance of any range, on that parallel, west of the Rio Grande. They are called, in Sonora and part of Chihuahua, the Sierra Madre mountains, yet they do not fulfil entirely the conditions implied by that term, for I am credibly informed that the waters flowing from their base towards the Pacific coast often take their rise to the east of these mountains, and flow through chasms impassable for men, and fall down the western slope in rapid descent, producing sublime and picturesque cascades.

RIO GRANDE—NEAR FRONTERA.

It was not in my power to explore this range to the south, but I was informed by persons worthy of confidence, that throughout its whole extent, as far south as the parallel of Mazatlan, it was utterly impassable for wagons, and there was no possibility of finding, south of 31° 20′, a line for a railway. The report of its impracticability for wagons was confirmed by the fact that the Camino real, (highway,) established by the Spaniards to connect Chihuahua and Guymas, makes a great circuit, and passes to the north of 31°.20, and within what is now the territory of the United States.

This stupendous range of mountains, which drops so abruptly a few miles north of the boundary, as if to make room for the highway which is to connect the Pacific and Atlantic States, no doubt, reappears to the north, in the neighborhood of the Gila, but our information is not yet sufficient to establish the connexion. I am quite satisfied of one thing, however; its equivalent is not to be found in what is called the Sierra Madre, in New Mexico.

Pursuing our course still eastward, we pass over wide plains bounded by detached ranges of mountains of metamorphic and other limestones, associated with igneous rocks, rich in silver and lead, and at El Paso we encounter the western flank of the third great mountain chain, the Rocky mountains, known in that particular locality as the Organ mountains; and at intervals of about eighty miles we cross two other ranges, the Eagle Spring mountains and the Limpia range of mountains.

The view will give a very good idea of the appearance of the Organ mountains in the distance, and of the Great Mesa, which reaches far away to the west. It is from the bed of the Rio Bravo, just above the gorge, where the river breaks through the range at El Paso.

These three chains of mountains appear to be spurs of the Rocky mountains, and are characterized by the presence of carboniferous limestone, greatly disturbed by igneous protrusions of what Professor Hall characterizes as of "comparatively modern origin."

And throughout this whole region, the carboniferous and metamorphic limestone is not unfrequently traversed by rich seams of argentiferous lead ore. Between the San Luis range and the Organ mountains, the first of the Rocky mountain range, the metamorphism of the rocks is so complete and the irruptive lines so frequent, and protrusion above the crust of the earth so detached, it is impossible to say, with our present information, where the one begins or the other ends, or whether they do not all belong to the same system.

It is between these two ranges, upon the banks of the Janos river, that we discover the first evidences from the west of that vast cretaceous formation which has been traced from the 108th to the 101st meridian of longitude, and as far north as the Great Salt Lake, and south to the 25th parallel of latitude.

The western limit of this formation, discovered by the boundary survey, is the basin of the Janos river in Chihuahua, and its easternmost limit San Antonio, in Texas. How far it extends north and south has never been ascertained, but it has been traced in one direction as far as the Big Salt Lake of Utah Territory.

Granite, and its associated gold-bearing rocks, occur sporadically throughout the Rocky mountain chain, and its spurs; but the distinguishing feature, in an economical point of view, is the prevalence of carboniferous limestone, with which is found associated argentiferous galena.

Silver mines of richness have been discovered, and some of them worked to a limited extent, in the mountains about Tucson, at Barrancas, Presidio del Norte, Wild Rose Pass, in the Organ mountains, and other localities, accounts of which will be found elsewhere.

Gold mines have been worked at the Calabasas, on the Santa Cruz river, and in the mountains of New Mexico, on both sides of the Rio Bravo.

It will not be extravagant to predict the discovery of many localities where silver mines can be worked to advantage throughout the whole region where carboniferous limestone exists, extending on the line of boundary from the great bend of the Rio Bravo, in Texas, to the meridian of the San Luis range. Should this conjecture prove true, we shall have then, in abundance, the only commodity in which we are now deficient, and for which we are at all dependent upon any other country.

Another argentiferous region of exceeding richness, and, I think, one wholly disconnected from the other, is in the basin west of the Santa Cruz river, between that river and the Gulf of California. Veins of metal were discovered traversing a coarse sandstone, which will be more particularly referred to in Chapter VI on that section of the boundary.

I have stated that the eastern portion of the continent, with which we are familiar, is entirely different in its physical geography from the western, and among the distinguishing features of the first is the Appalachian chain of mountains, which sheds its waters clear from the summit to the ocean; that is to say, water once above the surface at any point, continues to flow in that position until it reaches tide-water.

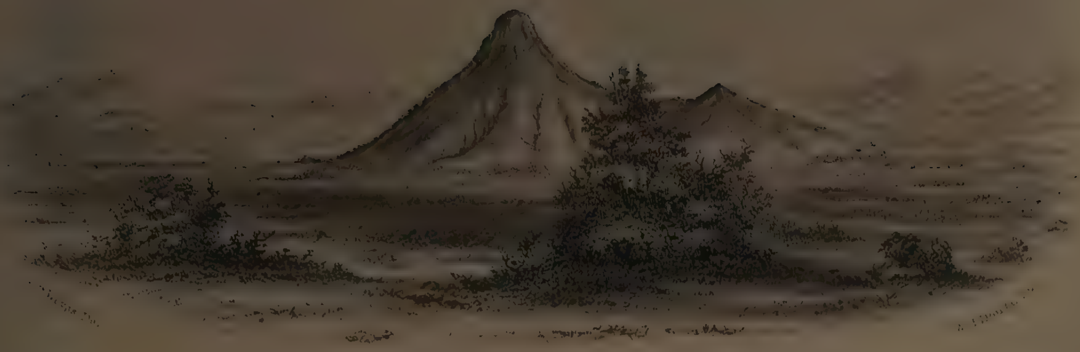
Between the two great chains, which I have attempted to describe, occupying the western portion of the continent, there are other chains of mountains, so numerous that it is impossible to describe them by words; some are continuous, some are detached ridges, others isolated peaks, rising from the plateau almost with the uniformity and symmetrical proportions of artificial structures. Between them are found basins, which have no outlets to the ocean, but are the receptacles of the drainage of the surrounding water-sheds. Of these, the most extensive is the Great Salt Lake in Utah Territory, and the most remarkable for its historical associations and present importance is the valley of the city of Mexico.

These successions of basins form a prominent feature in the geography of North America, extending two-thirds its length, and quite one-third its breadth. They belong to what has been appropriately designated as the Basin system of North America.

Those found near the boundary are Santa Maria, Guzman, and Jaqui—all to the south of the boundary, and within the limits of Mexico. The first is fed by the waters of the river Santa Maria, which runs in a northern direction, and Guzman by the river bearing the several names of Casas Grandes, San Miguel, and Janos, the general course of which is also from the south to the north; and the waters of Lake Guzman and Lake Santa Maria are said to unite in seasons of unusual freshets.

The waters of the Rio Mimbres, near the same meridian as Lake Guzman, which take their rise near the Santa Rita del Cobre, run towards that lake, but they disappear in the plain to the north of the boundary, before reaching it.

The waters of these lakes, or inland seas, are brackish at all times, but in seasons of drought, which last two-thirds of the year, they become salt, and wholly unpalatable. Their shores are covered with lacustrine deposites, and are usually unsuited to cultivation. The waters of these vast basins are not all locked up, however, by the mountains. Three great rivers, with their tributaries, have made their way in different directions to the ocean, cutting, in their passage, gigantic chasms in the mountains. These rivers are the Columbia, the Colorado of the West, and the Rio Bravo. Another river, the Gila, drains this plateau, cutting the mountains nearly at right angles, which, although a tributary of the Colorado, joins it near its



OJOS DE LOS ALAMOS VIEJOS

mouth, and at an elevation so little above the sea, that it may, in a general description, be considered a separate and independent drainage.

Another feature of this basin system remains to be described, which is also common to all the rest of the mountain regions occupying the plateau, and the region lying east of the Rocky mountains. Between the ridges of mountains the traveller occasionally encounters vast plains, which, when the sun is above the horizon, producing the phenomenon of the mirage, present to him all the appearance of the sea. The plain bounds the view, and the line of the horizon is broken into waves, resembling, in appearance, the edge of the Gulf Stream, when seen from the deck of a vessel ten or fifteen miles distant. The plains are clothed with vegetation of a scrubby growth, incapable of affording subsistence to any but a class of small animals, such as antelope, prairie-dogs, and rabbits. Most generally, however, in the southern part of the United States, these plains are clothed with a luxuriant growth of "grama," the most nutritious of all the grasses. Sometimes they are destitute of all vegetation, except the larrea Mexicana, the yucca, the cactus, and other spinous plants, and are paved with minute fragments of chalcedony, basalt, agate, and other hard rocks. Occasionally in these plains we encounter sand-dunes, called by the Spaniards *medanos*, extending over a large area of country, and encircling what might at first sight be supposed the shores of dried-up lakes. But an examination of the sand with a microscope of sufficient power, dispels this idea. The grains seem to be angular, and are not rounded by the attrition of water. An extensive formation of this kind occurs between the Rio Colorado of the West and the base of the Sierra Madre, and extends many miles along almost the whole extent of the western coast of the Gulf of California. Another very extensive waste of sand lies to the south of the Arkansas river; a third is traversed by the Platte river; and a fourth, which has come under my notice, less in extent, lies to the south of the Rio Bravo, on the road from El Paso to the city of Chihuahua.

The plains or basins which I have described as occurring in the mountain system, are not the great plains of North America which are referred to so often in the newspaper literature of the day, in the expressions, "News from the plains," "Indian depredations on the plains," &c.

The term "plains" is applied to the extensive inclined surface reaching from the base of the Rocky mountains to the shores of the Gulf of Mex.co and the valley of the Mississippi, and form a feature in the geography of the western country as notable as any other. Except on the borders of the streams which traverse the plains in their course to the valley of the Mississippi, scarcely anything exists deserving the name of vegetation. The soil is composed of disintegrated rocks, covered by a loam an inch or two in thickness, which is composed of the exuviæ of animals and decayed vegetable matter. The growth on them is principally a short but nutritious grass called buffalo-grass, (Sysleria dyctaloides.) A narrow strip of alluvial soil, supporting a coarse grass and a few cotton-wood trees, marks the line of the water-courses, which are themselves sufficiently few and far between.

Whatever may be said to the contrary, these plains west of the 100th meridian are wholly unsusceptible of sustaining an agricultural population, until you reach sufficiently far south to encounter the rains from the tropics.

The precise limit of these rains I am not prepared to give, but think the Red river is, perhaps, as far north as they extend. South of that river, the plains are covered with grass of larger and more vigorous growth. That which is most widely spread over the face of the country is the grama or mezquite grass, of which there are many varieties. This is incomparably the most nutritious grass known.

South of the Red river, also, the plains are not unfrequently covered with a growth of mezquite trees, (algaroba,) of which there are many varieties. This tree varies in size according to the character of the soil and quantity of rain. It is usually from fifteen to thirty feet in height, crooked, gnarled, and armed with thorns. The wood is hard and full of knots, and is unfit for purposes of carpentry, but in other respects it fulfils many of the economical uses of life. It is excellent firewood, and makes good posts, being very durable. It exudes a gum which is equal to gum-arabic, but to the traveller its most important quality is the fruit which it bears—a nutritious bean, much relished by animals, and not wholly unsuited to the tastes of man.

The vegetation of the mountain and basin region, while it differs materially in the genera and species of plants according to the locality, possesses, nevertheless, a general similarity which is striking and peculiar. I have described that of the plateau or levels as consisting of a diminutive growth of shrubs; but as we ascend from these to the heights of the surrounding mountains we pass through a succession of floral products, varying in character according to the elevation to which we ascend, until we reach a sub-Alpine flora. North of the parallel of 32° this appears at the height of about six thousand feet above the sea.

In situations protected from the winds we usually find, at this height, pines and cedars, and at a less elevation different varieties of oak. Wherever this region is traversed by water-courses, cotton-wood and occasionally sycamore grow on the edges of the streams. There are throughout this region, on the sides of the mountains, growths of pine, oak, and cedar, which are quite extended and present a forest-like appearance, but nowhere, until we begin to descend the Pacific slope and get within the influence of the humidity from the ocean, do we encounter timber at all approximating in size or luxuriance of growth the forests with which we are familiar in the basin of the Mississippi and the eastern slope of the Alleghanies. The Pacific slope, including the water of the Sacramento and its tributaries below the Cascade range, and Puget sound and its tributaries, it is not my intention to describe in this general sketch, or the memoirs which follow, further than to say that, refreshed by frequent showers and fogs from the ocean, it presents a different and more inviting picture than the country to the east of it. It is on this slope that we find that stupendous growth of red-wood, the accounts of which appear almost fabulous. We find here, too, in all that region north of Monterey, considerable adaptation, both in soil and climate, to the production of the cereal plants. About Santa Barbara, in parallel 34° north latitude, the mountains run to the sea; thence the coast deflects sharply to the east; and below, or south of this point, the trade-winds, which sweep along the Pacific coast, charged with humidity for nine months in the year, from as far north as the Aleutian islands, seem to diminish in force, and finally die away, at the lowest extremity of California. The mountain range at Santa Barbara cuts off these humid winds from the land to the south of them; and it is my opinion, that on the Pacific slope beyond this point, and until we reach the region of the tropical rains, no crops can be raised with anything like certainty without irrigation. South of this range, the agricultural character of the country is much the same as that of the mountain and basin systems, and this character is retained along the coast until we reach the parallel of Mazatlan, where the tropical rains begin to be felt in great force. For the four months (July, August, September, and October) during which I kept a meteorological record at Camp Riley, no rain fell in sufficient quantity to be measured. The mean height of the barometer for that period was 29.853, the thermometer 68.37, and the mean dew-point 58.13.

There are considerable portions of the extensive mountain system which I have attempted to

describe, where wheat and rye can be raised without irrigation; but these portions are exceptions to the general rule; and I think I am safe in stating, that as a general rule throughout this vast region, corn, cotton, and vegetables cannot be produced without irrigation; and furthermore, the limits of the ground which can be brought under the effects of irrigation are very circumscribed. The town of El Paso, in latitude 31° 44′ 15″.7, and longitude 106° 29′ 05″.4, is considered, and justly so, one of the garden-spots of the interior of the continent. A meteorological record was kept at Frontera, a few miles north of this point, for two years, by assistant Chandler, the results of which are embodied in the diagram herewith presented.

From this it will be seen how very dry the climate is, and how unsuited for agricultural purposes, according to the notion entertained of farming in the eastern States. The settlements about El Paso are irrigated by the Rio Bravo, and are happily not dependent on rains for their fertility.

Whatever population may now, or hereafter, occupy the mountain system, and the plains to the east, must be dependent on mining, or grazing, or the cultivation of the grape. The country must be settled by a mining and pastoral or wine-making population; and the whole legislation of Congress, directed heretofore so successfully towards the settlement of lands east of the 100th meridian of longitude, must be remodeled and reorganized to suit the new phase which life must assume under conditions so different from those to which we are accustomed.

Southern California, the whole of the upper valley of the Gila, and the upper valley of the del Norte, as far down as the Presidio del Norte, are eminently adapted to the cultivation of the grape. In no part of the world does this luscious fruit flourish with greater luxuriance than in these regions, when properly cultivated. Those versed in the cultivation of the vine represent that all the conditions of soil, humidity and temperature, are united in these regions to produce the grape in the greatest perfection. The soil, composed of the disintegrated matter of the older rocks and volcanic ashes, is light, porous, and rich. The frosts in winter are just sufficiently severe to destroy the insects without injuring the plant, and the rain seldom falls in the season when the plant is flowering, or when the fruit is coming to maturity, and liable to rot from exposure to humidity. As a consequence of this condition of things, the fruit, when ripe, has a thin skin, scarcely any pulp, and is devoid of the musky taste usual with American grapes.

The manufacture of wine from this grape is still in a crude state. Although wine has been made for upwards of a century in El Paso, and is a very considerable article of commerce, no one of sufficient intelligence and capital, to do justice to the magnificent fruit of the country, has yet undertaken its manufacture. As at present made, there is no system followed, no ingenuity in mechanical contrivance practised, and none of those facilities exist which are usual and necessary in the manufacture of wine on a large scale; indeed, there seems to be no great desire beyond that of producing as much alcoholic matter as possible. The demand for strong alcoholic drinks has much increased with the advent of the Americans; and in proportion as this demand has increased, the wine has decreased in quality. On one occasion I drank wine in El Paso which compared favorably with the richest Burgundy. The production of this wine must have been purely accidental, for other wine made of the same grape, and grown in the same year, was scarcely fit to drink. Cotton and corn grow with luxuriance, where water can be brought to irrigate the soil, throughout the valleys of the Gila and Rio Bravo, and upon the lower Rio Bravo; and upon the Rio Colorado, below its junction with the Gila, sugar-cane flourishes.

It sometimes happens that the irrigation is produced by natural causes—the overflow of the river. This is the case in the basin of the Presidio del Norte, and on most of the country susceptible of tillage in the valley of the lower Rio Bravo. Crops depending upon this mode of irrigation are very uncertain, the overflows of the river being very unequal as to time and extent. In some portions, however, of the Rio Bravo there are two overflows. This is the case at the Presidio del Norte, below the junction of the Conchos river. The first overflow occurs in June, from the melting of the snows near the head of the Rio Bravo, in latitude 36° 37′; the second occurs in August, from the tropical rains which fall on the mountains near the sources of the Conchos, in latitude 26° 28′.

This occurs to a limited extent on the lower Rio Bravo, which is principally supplied in the summer months by its tributaries—the Salado, the San Juan, &c. These take their rise in the mountains to the south, within the regions of tropical rains. How far the lower Rio Bravo is supplied by the melting of the snows at the head of the river, I am not prepared to say; but I am inclined to the opinion that, before reaching the tertiary region near the mouth of the river, most of the waters from that source are expended either by evaporation or absorption. In the intermediate portion of the Rio Bravo, that lying between Valverde, north of which the river is kept running by the melting of the snows throughout the summer, and the Presidio del Norte, where the Conchos joins it, and supplies it with water from the tropics, great inconvenience is felt for water in years of unusual drought. I was informed, on good authority, that in the summer of 1851 a man drove a gang of mules along the bed of the river from the Presidio del Norte to El Paso. The bed was dry for nearly the whole distance, occasional pools of water standing in places where the river-bed was formed of rock or clay, impervious to water. It was always possible, however, to procure water in sufficient quantities for drinking or watering animals by digging in the river-bed a few feet below the surface.

It might be expected in this report that I should say something of the practicability of a railway route to the Pacific through the newly-acquired territory; and it was my intention to do so, but the subject has been so ably and thoroughly examined and discussed by the Secretary of War, and the officers of the Topographical Engineers acting under his orders, as to leave nothing more to be said. All the topographical and other knowledge bearing on the subject which has been acquired by the boundary survey has been freely placed at the disposal of the War Department. The signal ability with which that information and the information acquired by the surveys specially ordered for the purpose have been collated, leaves nothing for me to say, except that our information fully sustains the conclusions of the War Office report; and it is decided, beyond all question, that a practicable, and, indeed, a highly advantageous route, from the upper basin of the Rio Bravo to the valley of the Gila, exists through the new territory.

It has already been stated, as one of the facts elicited by this and previous surveys, that if the sea were to rise four thousand feet, a vessel could pass from the Gulf of California to the Gulf of Mexico, near the parallel of 32°, and that north of that parallel no good road even for wagons could be found, uniting the valleys of the Bravo and Colorado rivers. This remarkable fact was noticed by me in a reconnoissance made in 1846–'47, and was first brought to the notice of the government through Mr. Buchanan, then Secretary of State, who immediately sent a despatch to our minister in Mexico, indicating that no boundary north of that parallel of latitude should be accepted. The treaty of Guadalupe Hidalgo, however, fixed a line north of that parallel, which cut off entirely the communication by wagons between the two rivers;

and leaving out of view the consideration involved in securing a railway route to the Pacific, it was a line which must sooner or later have been abandoned. No traveller could pass, nor could a despatch be sent, from a military post on the Rio Bravo to one on the Gila without passing through Mexican territory.

I again called the subject to the attention of the government in a letter dated San Diego, April, 1850, which has been already given, in the hope that the United States commissioner might succeed in torturing the treaty of Guadalupe Hidalgo to embrace a practicable route. That letter, however, received no attention, and I am now of the opinion that the Mexican commissioner was so impressed with the importance of the advantage to his government of making a boundary which would not only exclude the railway route, but which would cut off the communication between our military posts in New Mexico, on the Rio Bravo, and those we might establish on the Gila, that any attempt to construe the words of the treaty so as to embrace the railway and wagon route would have been abortive.

It was a great mistake to suppose, as was urged at the time, that the line projected and claimed by the United States surveyor, in opposition to that agreed to by Mr. Bartlett, gave the United States this route. Subsequent surveys have entirely sustained what I have stated on this subject in the letter to the Secretary of the Interior, dated Fort Duncan, which will be found in the first chapter of this report.

The report of Lieut. Parke, who made the recent survey for the railway route over this portion of the country, fully confirms the opinions expressed by me of the practicability of the route; and he has further reported, as the result of his examinations, that the San Pedro river offers the best route by which to descend to the Gila from the table-lands west of the Rio Bravo. I went so far only as to indicate it as a practicable route. Lieut. Parke gives it the preference above all others; and the most prominent of the reasons he assigns, is the important fact that this route affords water in abundance, and traverses valleys capable of continuous settlement.

It is no part of my business to criticise the blunders made in the treaty of Guadalupe Hidalgo, or to defend the provisions of the treaty of December, 1850; but it is undeniable that the last treaty has secured to us what before did not exist—a means of communication between the military establishments on the Rio Bravo and those on the Gila; and what is more important, it has secured what the surveys made under the orders of the War Department demonstrate to be the most feasible if not the only practicable route for a railway to the Pacific. But the importance of these considerations is very little when compared to the important pecuniary consideration secured by the same treaty, in the revocation of the 11th article of the treaty of Guadalupe Hidalgo. That article made it incumbent on the United States to keep the Indians living within our own territory from committing depredations on the Mexicans, and, by implication, imposed on the United States the obligation of indemnity for all losses resulting from failure to carry out the provisions of the treaty.

No amount of force could have kept the Indians from crossing the line to commit depredations, and I think that one hundred millions of dollars would not repay the damages they have inflicted. Whole sections of country have been depopulated, and the stock driven off and killed; and in entire States the ranches have been deserted and the people driven into the towns.

It is true, all this has not been done since the war, and would form no just claim against the United States; but those conversant with the history of Mexican claims against the United States will at once admit that the United States would have been fortunate if she could have escaped with paying real claims for depredations, whether committed before or after the war. I

should not be true to history if I did not state what is within my own personal knowledge—that companies were formed, and others forming, composed of persons of wealth, influence, and adroitness, who projected extensive schemes for the purchase of these claims, with the view of extorting them from the Congress of the United States.

I have said nothing in this sketch of the races of men which inhabit this vast western region. I have attempted only to present such a general view of the country as will prepare the reader for the more detailed description of each portion of the boundary line, and the memoirs of the assistants on the separate branches of geology, botany, and zoology, and the ethnographic information which will be found in the local geographical descriptions.

I give in its proper place a table of latitudes and longitudes determined by myself and assistants, and also those determined by others, which have been used in the projection of the general map which accompanies this memoir.

The mode in which these determinations have been made will form the subject of a separate chapter. It will be sufficient to state here, that the important points in the boundary have all been determined by the largest and most improved portable instruments—the latitudes with forty-six inch zenith telescopes, by Troughton & Simms, of London, and the longitudes by moon culminations, observed with telescopes of equal power. As the occasion for taking these large instruments into the interior of the continent, thousands of miles from navigable streams, will perhaps not again soon occur, I have aimed to produce results which would inspire sufficient confidence to make the determinations on the boundary the base of future and minor surveys in the interior of the continent. It has been suggested to me that all the astronomical, magnetic, and hygrometric observations should be published, particularly the observations on the moon and the moon culminating stars; but these alone would form a volume as large as the volume of observations made at the royal observatory at Greenwich, published annually.

The results of the observations made by me and under my orders, as fast as attained, have been given freely to all who asked for them; but I regret they have been used in several notable instances by officers of the government, and others, without due acknowledgment to myself or my assistants.

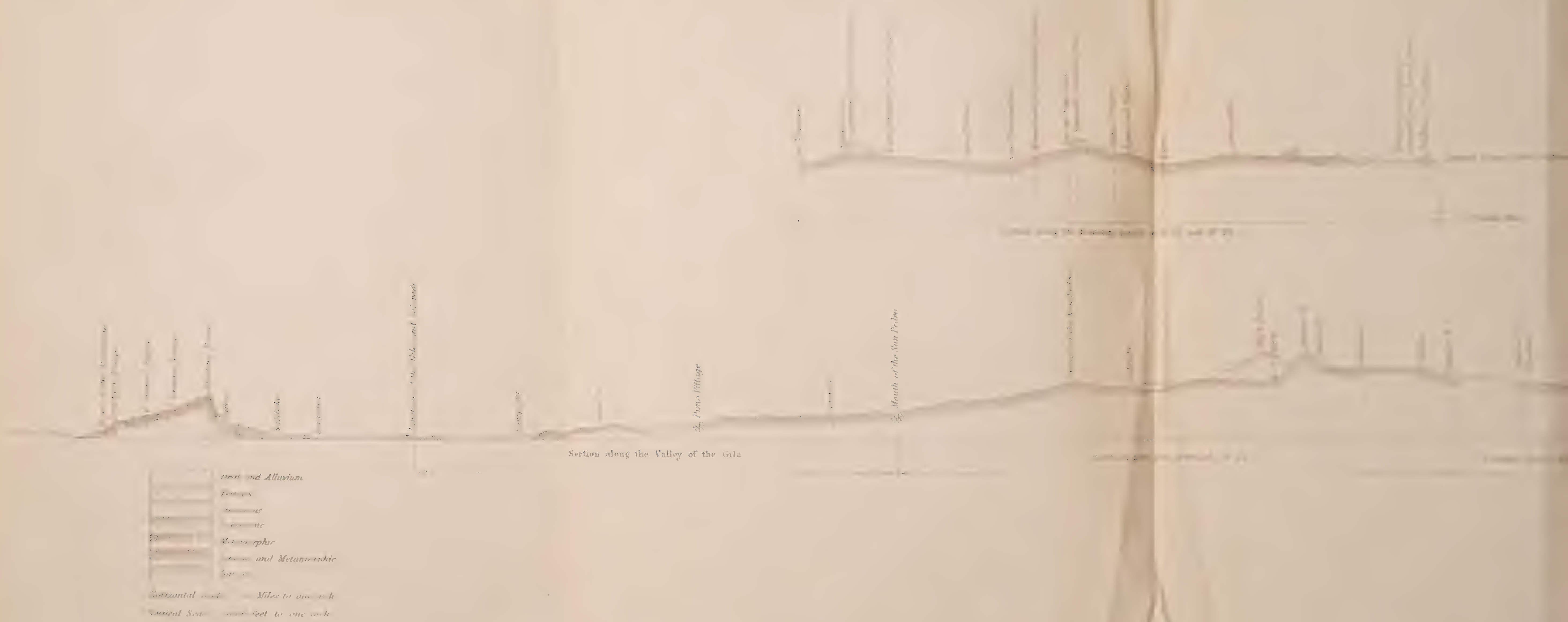
The best excuse that can be offered for such plagiarists is their ignorance of the labor, privation, self-denial and exposure incurred in the accurate determination of a single point in those far distant regions.

At none of the cardinal points have less than three lunations been used in the determination of longitude, and six nights for that of latitude.

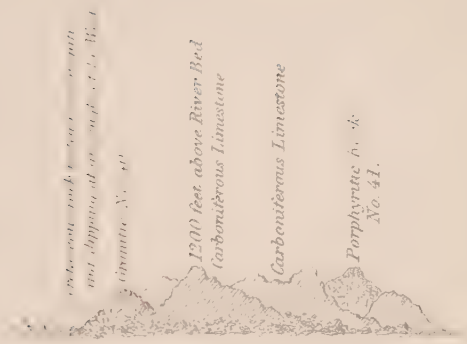
Arthur Schott del.

Lith of Sarony & Co. New York

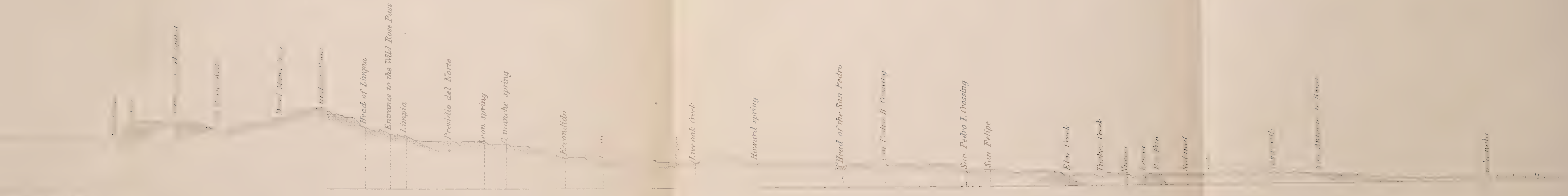
NOCO–SHIMATT–TASH–TANAKI
GRIZZLY BEAR
SEMINOLE CHIEF.



Section along the Valley of the Gila
Pimo Village
Mouth of the San Pedro
and Alluvium
Metamorphic
and Metamorphic
Miles to one inch
feet to one inch



Geological sketch of Mountains East of the Rio Bravo as seen from El Paso



Section along the road from Indianola to El Paso

SECTION

constructed from Surveys under the direction of

W. H. EMORY, U. S. Commissioner.

The Geological character of the formations

determined by C. C. PARRY

from collections made on the Survey.

CHAPTER IV.

LOWER RIO BRAVO.

BRAZOS SANTIAGO AND MOUTH OF RIO BRAVO AS PORTS OF ENTRY.—POINT ISABEL.—PALO ALTO.—RESACA DE LA PALMA.—COAST.—HURRICANES.—TIMBERED BELT.—COUNTRY WEST OF RIO NUECES.—MUSTANGS.—BURRITA.—BROWNSVILLE.—FILLIBUSTERING.—REYNOSA.—RINGGOLD BARRACKS.—ROMA.—POPULATION.—ISLANDS.—RIO SALADO AND BELLEVILLE.—LOREDO.—RAPIDS.—FORT DUNCAN.—SPANISH RULE AND MISSIONS.—AMALGAMATION OF RACES.—DEVIL'S RIVER.—NAVIGATION.—CAÑONS.—MEXICAN SIDE.—STATISTICS.—DISTANCES.

The general view which I have attempted to sketch of the region traversed by the boundary, will prepare the reader for the more minute description of the different sections of the country, and the individual reports of the assistants. It will not be convenient to arrange these sections in the order in which the work was pursued, nor to follow the order in which the general view was presented, commencing on the Pacific, and ending on the Gulf of Mexico. The order has been reversed. The first section embraces the lower Rio Bravo, from its mouth up to its junction with Devil's river; the second, the Rio Bravo, from the mouth of Devil's river to the initial point of the treaty of 1853, in the parallel of 31° 47′; the third, the line west to the intersection of the 111th meridian; the fourth, the line thence to the Pacific.

It will be remembered that I stated in the Personal Account, that in the year 1852, while engaged under the old commission, I found it necessary to suspend the work after bringing it as far down the river as Loredo. The following year, under a new appropriation by Congress, and a new organization, I sailed from New Orleans in the month of May, in a miserable steamer, for the mouth of the Rio Bravo, accompanied by a well organized party, with a complete set of instruments, camp equipage, &c. In crossing the Gulf, the sea was happily smooth, and it was not until we neared the coast and encountered the trade winds, which blow there almost ceaselessly from the southeast, that it became very rough. The steamer did not enter the mouth of the Rio Bravo, but steered her course towards the Brazos Santiago, eight miles up the coast. It was a long time before a pilot could be got on board, and then we were informed the sea was running so high on the bar, it was impossible to cross, and we were reduced to the necessity of lying "off and on" until the sea ran down. The captain gave orders to the mate to put the vessel's head to sea and stand out until day-break, under easy steam, and, with the pilot, went to sleep. The mate, a silly young man, addicted to intemperance, had made several remarks which destroyed my confidence in him, and having much at stake in the safety of the vessel, I did not go to bed. It was fortunate I did not, for, while dozing on the upper deck, I was gradually aroused by a roaring, seething sound, and on looking forward, saw that we were going head on to the breakers. There was no time to wake the captain, and I gave the alarm to the man at the wheel, and ran to the engineer to make him put on all steam. For many moments it was doubtful if the vessel could be got round. By great exertion, however, the steam was raised, and she barely escaped what appeared to be inevitable destruction.

The next day the sea continued to run high, and being thoroughly disgusted with my sojourn aboard the steamer, I went ashore in the pilot-boat.

The steamer was stranded a few trips subsequently, in attempting to make the entrance of the Brazos Santiago.

The bar has but eight feet of water, and is very shifting. That at the mouth of the Rio Bravo has still less. Yet it was at these two points that the troops were landed, and all the supplies for the army which invaded Mexico, under the orders of General Taylor. Most of the merchandise intended for the lower Rio Bravo is landed at the Brazos, and thence reshipped in a strong river steamer, which passes out to sea and thence into the Rio Bravo. The channel of the mouth of the Rio Bravo varies a little in depth, but is seldom more than six feet or less than four; it is of soft mud, and of the numberless vessels grounded there during the war, not more than one or two were lost. The bar of Brazos Santiago is of hard sand, and a vessel grounded there is certain to be stranded. The mouths of both these harbors open towards the prevailing wind, and I can suggest no method by which they can be improved at any reasonable cost. The town of Brazos stands on a sand-spit immediately within the bar, and is little more than a collection of wooden shanties, left there by the army, which may be washed away some day by a norther forcing the water from the lagoon, or bay, above, faster than it can escape over the beach and through the narrow inlet into the sea.

Three miles within the lagoon, or bay, and standing upon the first firm ground, a bluff of alluvial soil, about six or ten feet high, is Point Isabel. Here is the custom-house, where the goods intended for the river, as high up as Roma, are entered. Those for the towns above that point are supplied usually by the way of Indianola and San Antonio. Point Isabel is a small settlement, the principal buildings being those erected by the army of occupation in 1846. It was from this point the army made its march to fight the battles of Palo Alto, Resaca de la Palma, Fort Brown, &c.

It is well known that the Mexicans selected their own ground for the two first named battles; but if General Taylor had had in his hand the correct map now presented of that country, as will be seen by a glance, he could not have selected, in the neighborhood, a better field than Palo Alto to fight a small force against a larger one. This fact may have been known to others, but was not developed to my mind until the completion of this map. It will be seen that both flanks of the American army were protected, and the Mexicans were prevented by the ground from using the advantage due a much superior force to extend their flanks and envelope the American forces. The country is almost a dead level, and presents to the view of a horseman one unbounded plain, relieved by clusters of mezquite trees, (chapparal,) and the existence of the morasses to the right and left of the American position was probably not known to the Mexicans until they attempted to outflank their adversaries.

It was not my good fortune to have been present at either of those engagements; but I trust some of those who were will take advantage of the map now furnished, to figure for the military student the position and manœuvres of the troops on both sides, in those battles, so unique in their execution and results. Those two battles gave the prestige to our arms in the Mexican war, and saved the United States Military Academy from destruction.

The Mexican army was well organized, well disciplined, and well equipped, inured to war by contests with the Indians, and in suppressing internal revolution. The American army was perfectly disciplined, but, with the exception of its chief, and a few other gallant old officers, had never been under fire, and numbered only one-third of the opposing force. Yet on

their first encounter, the subordinate officers, chiefly from West Point, executed their orders with the precision of a field day exercise, showing beyond all question the utility of military education and discipline, and putting to rest at once the attacks on the Military Academy, which had become so formidable that few believed it possible to sustain the institution a year longer.

The general description of this part of the country will apply equally to all the coast of Texas, from the mouth of the Rio Bravo to the bay of Corpus Christi—indeed to Matagorda bay. It is well known to be a low, flat coast, with soundings diminishing regularly in depth as you approach the shore. The first shore-line is that of an island varying from some hundred yards to several miles in width, and penetrated at various points by inlets with shifting bars, few of which are practicable for the entrance of even the smallest sea-going craft. Separating this from the main land are shallow lagoons, as variable in breadth as the island which separates them from the ocean.

When the army marched from Corpus Christi to Point Isabel, General Taylor attempted to transport his supplies by the lagoon separating the two places, but found it impracticable even with small boats. These lagoons abound in delicious fish and fowl.

Proceeding inward, the land bordering the lagoons is, in the first ten or twenty miles, usually a flat prairie, composed of alluvial soil and sedimentary deposites of the ocean in alternate layers, showing how gradual and well contested have been the encroachments

Laguna below Lomita, fifteen miles above mouth of Rio Bravo del Norte.

of the land upon the sea. The rivers taking their rise in the cretaceous formations, both the sedimentary and alluvial deposites are heavily charged with lime, making the soil rich, black, and fiery—often so surcharged as to destroy some descriptions of vegetation. Within this belt, salt lakes of value are not unfrequently found, and throughout its whole extent spots

occur devoid of vegetation, and encrusted with a white saline deposite. Most generally, however, the vegetation is a luxuriant coarse grass which grows nearly waist-high, with an occasional clump of live oak bordering the wet places. I think it likely this whole belt of country has been formed in the following manner: the trade-winds from the southeast are felt here with considerable force, and, blowing inward for nine-tenths of the time, fill the lagoons with salt water. Suddenly the wind will shift in a contrary direction, and blow with violence for two or three days, called there a norther, forcing the salt water out to sea, and leaving the dry places to be covered by fresh water, thus forming alternate layers of salt and fresh water deposites.

This coast, as well as the whole coast of Texas, is sometimes swept by terrific tornadoes, which produce marked changes in its topographical and hydrographic features. In the latter part of the month of September, 1854, on my passage in the steamship Louisiana from New Orleans to Indianola, we encountered a violent hurricane. A few days afterwards we entered the mouth of Matagorda bay, and found the channel had been improved by the storm. It was deepened two feet, and instead of finding only nine, we found eleven feet of water on the bar, and the channel straightened. This beneficial effect remains, I am told, to this day. This hurricane, which swept the town of Matagorda level with the ground, and destroyed every wharf in the bay of Matagorda, except that upon which our instruments were placed, forced the water out of the bay at such a rapid rate, that it could only escape by deepening and widening the channel.

After passing the belt of prairie, we find a ridge of low sand-hills which seem to have marked the former limits of the coast, and here for the first time going towards the interior, we meet with clumps of post-oak called *mots*. The trees are usually crooked and wind-shaken, and unfit for timber.

Throughout this second belt or steppe, which extends many miles into the interior, wherever sand occurs to give consistency to the limestone soil, we find this growth in great abundance.

This admixture of soil produces the richest cotton and corn-growing soil in the world; but west of the Nueces, and between that river and the Rio Bravo, the want of rain makes agriculture a very uncertain business, and as we approach the last named river, this aridity becomes more marked, and the vegetation assumes a spinose stunted character—indeed, so marked is the change, that when we get within a few miles of the river the vegetation is a complete chapparal.

West and south of the Nueces the country is sometimes exposed to excessive and long continued droughts, and it is doubtful if agriculture can be made profitable without irrigation; all the region between that river and the Rio Bravo is, however, a fine grazing country, and the numbers of horses and cattle that ranged it, belonging to the settlers on the Rio Bravo under the Spanish rule prior to 1825, are incredible. To this day the remnants of this immense stock are running wild on the prairies between the two rivers. Hunting the wild horses and cattle is the regular business of the inhabitants of Loredo and other towns along the river, and the practice adds much to the difficulty of maintaining a proper police on the frontier to guard against the depredations of Indians and the organization of fillibustering parties. In times of agitation and civil war on the Mexican side, parties assemble on the American side ostensibly to hunt, but in reality to take part on one side or the other in the affairs of our neighbors. I had heard a great deal of these wild horses, but on an examination of many hundred that had been caught, I never saw one good one. They are usually heavy in the forehand, cat-hammed, and knock-kneed. Their habits are very peculiar; they move in squads, single file, and seem to obey implicitly the direction of the leader. They evince much curiosity, always reconnoitring

the camp of the traveller at full speed, and when there chances to be a loose animal, be he ever so poor and jaded, he is sure to run off with the crowd and disappear entirely. Many a luckless horseman passing through this country has been left on foot by the "stampede" caused by the visits of these wild animals.

Passing through that region in 1852, after a long journey of several thousand miles, my animals so jaded and worn down that I considered nothing could stimulate them to a gallop, my line was charged by one hundred and fifty of these animals, and six mules with a heavy wagon, containing all the astronomical and other instruments of the boundary commission, followed them across the prairie at full speed for nearly two miles. The coolness of the driver, and the boldness of the wagon-master, who threw himself in front of the lead-mules, stopped their further progress.

The section of country, particularly that part under consideration, is traversed by deep gullies called arroyos, sometimes difficult to pass in wagons. The sketch here presented shows one of these arroyos crossed by the road leading to Loredo.

Arroyo Secate, two miles below Loredo.

These arroyos are natural consequences of the unequal manner in which the rain falls throughout the year. Sometimes not a drop falls for several months; again, it pours down in a perfect deluge, washing deep beds in the unresisting soil, leaving behind the appearance of the deserted bed of a great river.

The streams which are found in this country have their rise in limestone regions, and the water is very unwholesome even when the stream is flowing, but usually the beds of the streams are partly dry, and the water is found standing in holes. Superadded to its noxious mineral ingredients, it holds in solution offensive vegetable matter, and is disgusting to drink; yet it is

upon this water that our soldiers are kept nine-tenths of the time while watching and pursuing the Indians who are constantly making incursions from the Mexican side into the settlements of Texas. While the country was in the military occupancy of the Spaniards previous to the revolution of 1825, they provided against this inconvenience by making at certain stations great reservoirs of solid masonry to catch the rain-water. The remains of many of these wells were found, and they form one of the many external objects to be seen throughout the extent of the frontier which convey the impression that the country has steadily gone backwards since the days of the Spanish rule.

Having now given the general view of the country on the American side of the first section of the boundary, I will ask the reader to ascend with me the Rio Bravo along the boundary, where I will describe in detail all that is worth noting as high as the mouth of the Rio San Pedro, or Devil's river, from which point we will take a general view of the country on the Mexican side, comprising the States of Coahuila, Tamaulipas, and New Leon.

Before ascending the Rio Bravo, it may be as well to state that the appointments for the survey of the river consisted mostly of light boats unsuited to hydrographic work in the open Gulf; and not wishing to incur the expense of an outfit for the limited surveys required by the treaty, outside the river, I proposed, with the concurrence of the Secretary of the Interior, to obtain the co-operation of the Superintendent of the Coast Survey, who had several well equipped parties in the Gulf, and whose operations I knew would eventually be extended to that locality. Under this arrangement, by which the boundary commission paid the expenses incidental to changes in its original plan of operations, and by which it was agreed that the hydrography should be done by the Coast Survey, and the astronomy and topography by the boundary commission, Lieut. Wilkinson, in command of the brig Morris, repaired at the appointed time to the mouth of the river and made soundings, marked on sheet No. 1, by which we were enabled to trace the boundary, as the treaty required, "three leagues out to sea."

This survey was conducted in the summer of 1853, that in which the yellow fever scourged the whole Gulf coast; yet up to the time of leaving the station, late in the summer, no case of the disease had occurred on board the vessel, and but a single one among the land parties. In conformity with a promise made, I took passage in the "Morris," which was not entirely sea-worthy, and went with the party to Pensacola, where the yellow fever was raging, and we had to lament the loss of the surgeon, Dr. Bryan, whose high professional skill and many social virtues endeared him to all who were honored with his friendship. Several others of the party, myself among the number, were taken down and narrowly escaped the fate of Dr. Bryan.

The voyage across the Gulf, which should have occupied five days, was, owing to adverse winds, gales, and the condition of the ship, extended to eighteen days. I had an opportunity on this voyage to watch narrowly the effect of the storms on the barometer, and observed for the first time a fact which, I believe, has since been well established, that in the Gulf the fluctuations of the barometer fail to give the usual indications of the approach or subsidence of storms.

The entrance to the mouth of the Rio Bravo is over a bar of soft mud, varying from four to six feet deep, and the river within a few hundred yards of its mouth is not more than one thousand feet wide. The shore-line of the coast, scarcely broken by the action of the river, is formed of a series of low shifting sand-hills, with a scanty herbage. Inside these hills are numerous salt marshes and lagoons, separated by low belts of calcareous clay but a few feet above the level of the sea, and subject to overflow. The first high ground is Burrita,

ten miles from the mouth, where there is a small settlement of Mexicans engaged in agriculture upon a very limited scale.

Mouth of the Rio Bravo del Norte.

At the mouth of the river there are a few frame houses erected by the army in 1846, now owned by the steamboat company engaged in the navigation of the river. Opposite is a small Mexican settlement called Bagdad, where the Mexicans from the interior, as far as Monterey, resort for sea bathing. The sites on either side of the river are very unsafe. A few years before the Mexican war, the whole population was swept off except the pilot, an American, who, with his family, took refuge on the top of the sand-hill upon which my observatory was afterwards erected.

Beyond Burrita, the river still pursues its serpentine course through alluvial soil, with an occasional patch of arable ground occupied by Mexican rancheros engaged in the cultivation of maize and the rearing of goats and chickens.

At the Rancheria de San Martin, a mouth of the Rio Bravo, forty feet wide, opens on the American side into the Laguna Madre, allowing some of the water of the river to escape to the sea by the Boca Chica and the Brazos St. Iago. On the American side the road leading from the mouth of the river to Brownsville crosses this outlet at San Martin, over a substantial wooden bridge erected by the army.

From this point upward to Brownsville the river makes a great bend to the South, and is so winding in its course that frequently the curves almost touch. The land on each side is level, and covered with a dense growth of heavy mezquite, (Algaroba.) It is generally too high for irrigation, and the climate is too arid to depend with certainty upon rain for the purposes of agriculture. The vegetation is of a semi-tropical character, and the margin of the river, which is exposed to overflow, abounds in reed, canebrake, palmetto, willow, and water-plants, and would no doubt produce the sugar-cane in great luxuriance.

Brownsville, situated on the American side of the river fifty miles from its mouth by the course of the river, is only twenty-two miles distant by the road. It contains about three thousand inhabitants. The houses are mostly of wood and well built. The town has sprung up since the Mexican war, and owes its prosperity chiefly to the contraband trade with Mexico.

Opposite Brownsville is the ancient town of Matamoras, with a population about the same in number as Brownsville.

Old Fort Brown, Texas.

Below Brownsville, and adjoining it, is the military post, with old Fort Brown at the farthest extremity of the public grounds. In the middle of the parade ground, unmarked by any monument, lie the remains of the gallant officer who fell in defence of the fort which now bears his name. The height of Fort Brown above the sea is, by barometrical measurement, fifty feet. The mean temperature for the years beginning 1850, and ending 1855, was 73° Fahrenheit; the mean quantity of rain in the same years was annually 33.65 inches. These quantities are taken from the Army Meteorological Register, and are used in preference to my own, as they cover a much longer space of time. They would seem to indicate an abundance of rain for all the purposes of agriculture, and we should be at a loss to understand the arid character of the country on both sides of the river, were it not that the tables give us the solution; we there find that more than one-half the rain falls in the autumn, which is followed by a winter during which the thermometer frequently falls below the freezing-point. One-fourth the whole quantity of rain falls in a single month, and it very often happens that no rain whatever falls in the months of May, June, and July. Consequently, throughout the whole valley of the Rio Bravo and its tributaries, we seldom see corn growing except in the bottoms, subject to over-

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flow, or upon lands which are below the water-level and can be irrigated by artificial channels. Somewhat of this barrenness is due undoubtedly to the excess of lime and saline matter with which the soil is charged.

As we ascend above Brownsville, lands within the water-level become more frequent and extended, and at many places cultivated fields form a prominent feature in the landscape. Up as high as Reynosa, the belt of alluvial soil subject to the influence of the moisture from the river is very considerable in width, and in addition to corn, the sugar-cane has been planted with success. The foliage on this portion of the river indicates a richer soil, and the trees assume very much the dimensions of those on the alluvial bottoms of the Mississippi.

It is within this region, embracing a river coast of one hundred miles, that the sugar-cane can be cultivated to advantage; and in situations sheltered from the northers, I have no doubt oranges and lemons could be raised with facility.

Property, however, is very insecure all along the boundary, and unless extradition laws with Mexico are passed, this fertile tract will never have its capacities developed.

The boundary between the United States and Mexico is here only an imaginary line running down the centre of the river, and an offence can be committed on either side with impunity. A few minutes served to place the offender over the line, when the jealousies of the law on either side step in to protect him; and where national prejudices are involved, the criminal is not unfrequently extolled for his exploits.

It was in the summer of 1853 that this portion of the boundary was surveyed, and a revolution headed by Caravajal was in its last throes. This chief had retired to the American side of the river, and was occupied in making occasional forays into Mexico, aided by some American volunteers, mostly composed of young men, whose tastes for civil pursuits had been destroyed by the Mexican war. These efforts were attended with no other effect than that of irritating the peaceable inhabitants on both sides, and were of great inconvenience to us in the prosecution of the survey. Attempts were made several times to stop the parties under my command engaged in the survey of the river, and on one occasion nothing but the forbearance of the officer in command prevented his party from firing upon a detachment of Mexican cavalry which threatened to charge them. In the absence of the Mexican commissioner, I was at length compelled to make a direct appeal to General Cruz, then in command on the Mexican side, who promptly gave orders along the line which had the effect to lessen, in some degree, the interruptions to which the surveying parties were exposed.

We were scarcely more in favor on the American side of the line; for some months previously the United States troops had interfered with a strong hand to break up the enlistment of men and the concentration of fillibustering forces on our side of the river. Although most of the hired men employed by me were disbanded fillibusteros, the parties escorted by a detachment of United States soldiers were usually mistaken for military scouts in search of the violators of the law, who at that time composed the majority of persons on the frontier.

Some idea of the reckless character of the persons then infesting that frontier may be formed from the following circumstance, the truth of which is vouched for by several respectable eye-witnesses. My own camp was but a short distance from the place where the scene occurred:

One mild summer's evening several gentlemen, among them a retired officer of the fillibusteros, were enjoying the delicious twilight of that climate on the bank of the river opposite a point where was usually posted a picket-guard, detached from a Mexican military station four miles distant. The guard of ten men were seen to approach the jacal, dismount, tie their

horses, and stretch themselves on their blankets, some to sleep, others to smoke, but none particularly to watch.

The conversation of the first-named party was rather of a jocose character, directed at the expense of the young American fillibuster who had joined in the Caravajal revolution, which had just been ended with such signal advantage to the regular Mexican troops. A little nettled, probably, at what had passed, he offered a wager of one hundred dollars that he would cross in a boat and take the guard, single-handed. His wager not being accepted, he offered to bet "drinks for the party." Some person, not dreaming he was in earnest, indiscreetly took the bet.

The absence of the fillibuster was scarcely noticed, and the conversation about other subjects had continued for nearly an hour, when it was interrupted by the sharp reports of a revolver, and a yell which reverberated from shore to shore, giving the impression of many voices; these were quickly followed by the rolling fire of a platoon of musketry, and then all was silent. "Could that be S——?" asked one. "Impossible!" was the reply. "It would be just like him," said a third. Shortly after a boat containing two or three men was seen to dart across the rapid current from the shadow of the high bluff on the American side. As it approached the opposite side, its occupants, not wishing to violate the usages of the guard, called out in Spanish they were friends, going over to see what was the matter. "*Matter? Hell!*" answered a voice in English, "Come here and help me to drive these mustangs in the river." They found the guard dispersed, and S—— with one arm shattered by a musket-ball; with the other he was trying to lead all the ten horses to the river-shore.

Reynosa is a small Mexican town of about 1,500 inhabitants, opposite an American settlement called Edinburgh, with one or two substantial warehouses. The last-named town, like all the others on the American side, except Loredo, has been built since the war, and owes its existence chiefly to the contraband trade with Mexico. Reynosa is built on a low cretaceous ridge, and it is here the first rocks above the surface are seen; yet none appear on the immediate banks of the river until we reach Las Cuevas, some distance above, where we find a stratum of cretaceous sandstone 10 or 15 feet thick. At the last named point, and thence up the river, there is also a marked diminution in the quantity of bottom-land susceptible of cultivation, and vegetation changes its character, becoming more dwarfed and spinose. The uplands on either side impinge close upon the river, and the vegetation is principally mezquite and cactus. On the Texas side, as we recede from the river, the chapparal gives place to the open prairie, covered with luxuriant grass. This character of the river lands extends with little variation up to Ringgold Barracks.

This military post consists of a few comfortless frame houses, situated half a mile below Rio Grande city. Opposite, and four miles from the Rio Bravo, is the town of Camargo, of about one hundred inhabitants. It is situated on the San Juan river, the first unfailing tributary to the Rio Bravo from the Mexican side. It is one of a series of rivers which rise in the so-called Sierra Madre, and go to supply the Rio Bravo in summer, the season of tropical rains, when that river most requires replenishing, as then the supply of water from the melting of the snows at its northern sources is nearly exhausted.

Ringgold Barracks was one of the points selected for the close determination of latitude and longitude to check the lineal surveys, and a point from which excursions could be made with facility, to determine secondary points by reflecting instruments and by the transmission of chronometers.

The result of the astronomical observations, and some of the observations themselves, will be found in the Astronomical Appendix.

Ringgold Barracks and Rio Grande City.

Through the courtesy of Major Paul, the commanding officer at Ringgold Barracks, the observatory was placed within the enclosure of the military grounds, and west of the officers' quarters. The height of this point above the sea, by the barometer, is 521 feet; the magnetic dip 52° 27′, and the declination 9° 15′ east. The observatory was 70 feet above the bed of the river, so that the river-bed is 451 feet above the sea at this point. The distance to the sea, measured by the sinuosities of the river, is 241 miles; the direct measurement only 75 miles. If the river had a direct run to the level of the sea, it would have a fall of six feet to the mile, and would probably empty itself in dry seasons, so that the tortuous course of the river, so vexatious to the traveller, is of importance in an economical point of view. My observations embraced three summer months at Ringgold Barracks, during which time the excessive heat was tempered by the sea-breeze, which was felt here daily with great force. Dr. Brown, assistant surgeon United States army, stationed at this post, has kindly furnished me with the meteorological journal kept by him for several years, and I give it in place of my own, as it extends over a much greater space of time, and will, therefore, afford a much more comprehensive view of the climate. It may, also, be taken as a fair type of the climate of that region of country which extends from Brownsville to Eagle Pass. It will be seen from this and subsequent records how dry the country becomes as we go towards the centre of the continent.

The beautiful town of Roma, 16½ miles above Ringgold Barracks, is the present head of steamboat navigation; it is built upon a high bluff of yellowish sandstone, containing ferruginous nodules. When I visited this small town, I was at a loss to know how such fine residences and warehouses, all recently built, could be sustained by its trade; but being the guest of the owner of one of these large establishments, I did not think proper to be very inquisitive. At night, when I went out to take my observations for the determination of the latitude and longitude of

the place, I found that the mercury of the artificial horizon was very tremulous, notwithstanding the calmness of the night. Not being able to overcome the difficulty, or ascertain its cause, I

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put up my instruments and returned to my quarters. On the way I encountered a long train of mules, heavily laden, directed towards the Mexican side of the river. The motion of the animals caused the disturbance of the mercury, and their rich burden of contraband goods, intended for the Mexican market, explained the commercial prosperity of the town. As might reasonably be expected in any country where the duties on foreign goods amount almost to prohibition, smuggling ceases to be a crime, but is identified with the best part of the population, and connects itself with the romance and legends of the frontier.

Between Roma and Ringgold Barracks there is much excellent land susceptible of irrigation, and both banks of the river are thickly settled with Mexicans. There are many Americans in this part of the country engaged in trade, but I cannot, at this moment, recall to mind a single one engaged in agricultural pursuits. Sugar cane will grow on this part of the river, but the land is rather too elevated for that plant to be grown with profit. Indian corn is the staple product, and when extradition laws are enacted and enforced, and the Indians who periodically plunder the country are exterminated, the rearing of cattle will be followed with advantage.

After studying the character and habits of that class of Indians called wild Indians, and bearing in mind the mild and humane government extended over them by the missionaries of the Church of Rome, without producing any results, I have come to the deliberate conclusion that civilization must consent to halt when in view of the Indian camp, or the wild Indians must be exterminated. Nothing could exceed the judgment, perseverance, and humanity with which the various orders of the Catholic Church have pursued, for three hundred years, the work of redemption among these savages; but at the very moment when Christianity appeared most likely to triumph, the savages turned upon their benefactors and swept them from the face of the

earth. There are distinct races among the Indians as among the white men, and before the advent of Christianity they were divided into semi-civilized and wild races. The semi-civilized then, as now, cultivated the soil, lived in houses, some three stories high, and kept faith with each other, and it is among these that Christianity has made any permanent impression. The wild Indians were then, as they are now, at perpetual war with them, leading a nomadic life, defying all restraint, and faithless in the performance of their promises. They have but two settled principles of action—to kill the defenceless and avoid collision with a superior or equal force. In the early stages of my experience with these Indians, I was inclined to believe them maltreated, and to consider their present reckless condition the result of the encroachments of the white people upon their rights; but such is not the case—experience proved to me that no amount of forbearance or kindness could eradicate or essentially modify the predominant savage element of character. The semi-civilized Indians form, however, much the larger class of Indians on the Mexican frontier. Indeed, nine-tenths of the population of all Mexico are Indians, or have the blood of Indians coursing in their veins. A pure white, of unadulterated Spanish blood, is rather the exception than the rule. I do not know how far the effects of the sun can be considered to have bronzed the complexion, but it seemed to me the proportion of pure white in the northern States of Mexico bordering on the boundary, was greater than in southern Mexico, always excepting the cities of Jalapa, Puebla, and Mexico.

One of the most important duties of our survey was to determine to which side the islands in the Rio Bravo belonged. For this purpose it was agreed between the Mexican commissioner and myself to sound the river on each side of every island, and the centre of the deepest channel should be the boundary line. From the mouth of the river to Ringgold Barracks there are eleven islands, marked on the map from 1 to 11, commencing at the mouth, and this order of numbering the islands is observed until we reach the parallel of 31° 47′, where the boundary leaves the river. The sheets of the boundary, on a scale of $\frac{1}{600000}$, are numbered from 1 to 54, No. 1 being the mouth of the Rio Grande, and the numbers progressing regularly from the Gulf of Mexico to the Pacific. The islands are numbered on these sheets to indicate their geographical position, but they are represented also on separate sheets on a scale of $\frac{1}{6000}$, to show their topographical and hydrographic details, and to exhibit upon what data they have been allotted to the United States or to Mexico.

Up to Ringgold Barracks these islands are of little value, but above that they are of more importance. Islands Nos. 12 and 13, between Ringgold Barracks and Roma, both fall to the United States. No. 13, called on the maps Beaver island, divides the waters of the river into three parts, and the channel which lies nearest to the Mexican shore is so narrow that steamers can with difficulty pass through it, yet the branches are, by reason of their shallowness, wholly impassable for them. An attempt was made by the Mexican local authorities to arrest the steamboat in its passage through this channel, but not only the survey, but the actual experience of the navigator, proved the narrow one to be the true channel, and consequently the boundary between the two countries. The allotment of all the islands was made upon the condition of things as they existed when the boundary was agreed upon. The channel of the river may change and throw an island once on the Mexican side to the American, and vice versa, but neither the Mexican commissioner nor myself could provide against such a contingency, none having been anticipated in the treaty.

We however agreed, as far as that agreement may be worth anything, that in case the channel

of the river changed, the right of navigation through the new channel should remain unimpaired to both countries, but the jurisdiction of the land must remain as we had arranged.

Five miles above Roma, and opposite Mier, there is a large island called Los Adjuntas, which was awarded to the Mexican side. At present the channel is between the island and the American shore. Formerly the channel was very nearly equally divided on either side of the island, but during the occupation of Mier by the American troops a temporary causeway was constructed of loose stone, to enable the cavalry to cross their horses to the island for the purpose of grazing. This causeway, now nearly washed away, has given a permanent direction to the channel which rules the island out of our territory. At the lower end of the Los Adjuntas and on the Mexican side are tepid baths, luxurious for the robust, and valuable for a certain class of diseases. The springs which supply these natural baths are near them, and are supposed to possess medicinal virtues of a high order. They were supposed to be sulphur springs, but analyses of the water which I placed in the hands of Dr. Easter detected no trace of sulphuretted hydrogen.* The zoological character of the rocks from Reynosa, where the cretaceous formation was first noticed, up to Las Moras, a distance measured on the parallel of latitude of 144 miles, is much the same, while they differ in their lithological character. If any difference is to be noted in the zoological character of these rocks it is in the exposure, just above Roma, at the foot of the island of Las Adjuntas, and at several other localities in the neighborhood, of banks of fossil oyster-shells of great size, some of them measuring 18 inches in length.

I have noted at Roma the occurrence of sandstone studded with nodules of ferruginous iron. Throughout the section between the San Juan river and Loredo, septaria and strata of yellowish and green sandstone frequently cocur. Often the nodules of more durable substance project beyond the weather-worn surface of the softer sandstone, producing picturesque appearances.

The town of Mier, famed in the history of the war of independence of Texas, stands upon the Alamo river, four miles back from the Rio Grande, contains about 700 inhabitants, and is now chiefly noted for the superior quality of the blanket manufactured there. It was an important point during the war with Mexico, being the point where the road to Monterey diverges from the Rio Bravo, and where the supplies for the invading army were transferred from water to land transportation. From Mier upwards, the course of the river is more nearly north and south, and less winding in its course. The banks on either side become more abrupt and rocky, and for the first time in ascending we find a rocky bottom.

Forty-six miles above Roma, measured by the river, is Bellville, the trading establishment of a hospitable and enterprising gentleman who has built himself a warehouse something after the fashion of old feudal castles—not for the purpose of ornament, but for defence against the Indians

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*The following is the result of the quantitative analyses by John D. Easter. The whole quantity of solid matter was 0.6763 per cent., consisting of—

Silica	0.016586 per cent.
Botoreide iron	0.000754 "
Alumina	traces.
Lime	0.009389 "
Magnesia	0.009580 "
Sodium	0.243323 "
Chlorine	0.340470 "
Sulphuric acid	0.010180 "
Phosphoric acid	traces.
Iodine acid	traces.
	0.630282

Lith. of SARONY MAJOR & KNAPP, New York.

FALLS OF THE RIO SALADO.

and banditti of that country. Opposite, on the banks of the Salado, and four miles from the Rio Bravo, is the town of Guerrero. The Salado, like the San Juan, and the Alamo which comes in at Mier, is a clear stream, having its rise in the sierras of igneous and metamorphic rock to the west, and forms a true oasis in the wilderness of rotten limestone which is found on either side of the lower Rio Bravo, and which causes the waters of most of its tributaries to be brackish and unwholesome.

The falls of the Salado are seven miles above its junction with the Rio Bravo. A floral phenomenon exhibits itself on the Rio Bravo, which finds its explanation at these falls. Just above Roma, and thence to the mouth of the Salado, the cypress is found growing in the bed of the Rio Bravo, and it was a matter of conjecture why it should grow there and not elsewhere. On ascending the Salado to the falls, it was ascertained the principal growth on that river was cypress, and the trees in the Rio Bravo were evidently emigrants from this colony. It is to be hoped that this useful tree will continue its emigration downwards, where the country is now destitute of all building wood.

The land from Bellville to Loredo is not altogether barren; there are many flats on which the water of the river could be brought for the purposes of irrigation; but, until recently, the Indians have had entire possession of the country, and now they make continual forays, crossing and recrossing the river to elude pursuit, at some of the many fords which occur in the river. I was myself very near falling into the hands of a party of these savages. Passing in a wagon from Bellville to Ringgold Barracks, in one of our excursions to determine the astronomical position of the former place, accompanied only by assistant Clark and the driver of the instrument wagon, we struck the trail of a band of Indians, where two roads united, so close that the dust was still flying. We supposed at the time we were following on the heels of a gang of wild mustangs going to water. These Indians were pursued by Captain Granger of the rifles, and brought to bay just as they were crossing the river and making good their escape to Mexico. That energetic officer succeeded in killing the chief and several others, and capturing all their horses and arms.

In many instances, along this portion of the river, American capital has associated with it Mexican labor, in the attempt to open farms for the produce of grain and the rearing stock, but the incursions of the wild Indians, and the depredations of the semi-civilized and half-breed Indians, render such enterprises uncertain and unprofitable. After we ascend about thirty miles above Loredo, all settlements on the Texas side cease until we get in the immediate neighborhood of Eagle Pass.

At Loredo there is a very considerable Mexican settlement, which dates back to the times when the Spaniards occupied the country. It has at present fallen into decay, and derives its support principally from the United States garrison, (Fort McIntosh,) one mile above the town. Loredo was once the residence of proprietors of countless horses and cattle, which have been run off by the Indians. Some of them, escaping from their captors, have formed the source of the numerous herds of wild horses and cattle that are now roaming the prairies to the east and north, the pursuit of which affords the chief occupation of many of the inhabitants of the Rio Bravo.

The country around Loredo is much the same as that described about Ringgold Barracks, but is more elevated and more frequently intersected by dry arroyos, which give evidence of more frequent and copious falls of rain.

Here, too, the geological character of the country is a little changed by the frequent occur-

rence of strata of compact blue limestone, useful in building. The public buildings at Fort Duncan (Eagle Pass) are of this material. Other strata also alternate with the main stratum of cretaceous sandstone, composed of blue clay, more or less hard, and marls of various colors, and oyster breccia of solid consistence. In the neighborhood of the arroyo Sombreretillo, ten or fifteen miles above Loredo, three miles below Eagle Pass, and also at Eagle Pass, strata of lignite coal occur three or four feet thick. This coal is of great prospective value, considering the scarcity of wood in this country, and the probable demand for fuel when the rich silver mines of the mountains to the south are in full operation.

Between Loredo and Eagle Pass, or Fort Duncan, a distance of 120 miles, measured by the sinuosities of the river, the river, its banks and adjacent country, retain very much the same character; the obstructions in the bed of the river become more rocky, and the fall more precipitous. At one place, called the falls of Rio Grande, or the Islitas, the rapids are impassable, even in small boats, except in the summer months, when the river is swollen by the tropical rains which fall on the mountains to the south and west. These falls, or more properly rapids, are forty miles below Eagle Pass; just above, the old Mexican trail crosses by which the army under General Wöll invaded Texas in the war of Independence, and is the same by which the column of United States troops under General Wool invaded Mexico, to effect a junction with General Taylor, in the war of 1846.

Fort Duncan, five hundred miles from the Gulf, measured by the sinuosities of the river, is only 208 miles measured in a direct line. It is the westernmost of the military posts placed at intervals along the lower Rio Bravo. The town of Eagle Pass adjoins the fort, and is a place of some trade, having a few large warehouses, built of the bluestone obtained in the neighborhood. Opposite is the military colony of the Mexicans, called Piedras Negras (black rocks,) after the coal layers which crop out here. The view of this military colony here presented is not strictly true. The artist has taken the liberty of placing on the houses roofs of carpentry work. The houses are, in truth, only jacals; that is to say, poles placed vertically, with the interstices stopped with mud, and the tops covered in by thatched roofs. The garrison on the Mexican side, below this place, is composed of regular troops. This military colony is an establishment peculiar to Mexico, and similar establishments are to be found at several points higher up the river. The idea attempted to be carried out is to combine colonization and military defence. Each soldier is allowed a certain quantity of land, and is permitted to live with his wife and children, and not required to live in barracks. A certain quantity of land is cultivated for the benefit of the whole colony; beyond the labor required for this, and military service of rather irregular character, the time of each soldier is his own, and he is permitted to cultivate as much land as he pleases.

Under the Spanish rule, prior to 1825, this system was combined with the missionary power of the Catholic Church; and all those Indians now running wild from the Gulf of Mexico to the Gulf of California were brought under the benign influence of the church; and about the beginning of the present century had attained a state of semi-civilization which may truly be called the golden age of this, now, vast deserted country. Under the Spanish dominion, a cordon of military and ecclesiastical stations extended from sea to sea, over a distance of fifteen hundred miles. Military patrols passed regularly from station to station, and at each station great structures were erected for the accommodation of troops, for religious worship, and for the storing of provisions, the remains of which are still to be seen. Among them some of the most beautiful specimens of architecture on the American continent are still to be seen. The


A. Schott del. R. Metzeroth sc.

LAS ISLETAS—FALLS OF PRESIDIO DE RIO GRANDE.

two in most perfect state of preservation are the Mission of San José, a church on the San Antonio river, a few miles below the town of that name, a sketch of which is here given, and the Mission of San Xavier, on the Santa Cruz river, in the newly acquired territory, the view

Mission of San José, near San Antonio, Texas.

of which, I regret to say, has been lost. Most of the buildings at these stations, however, were erected of perishable materials, adobe walls, and thatched roofs. As soon as the thatches were destroyed, the walls were washed down nearly to their bases by the rains. The Indians were required to cultivate the soil, and their families were domiciled in the immediate vicinity of the station. The most active and intelligent warriors were incorporated into the ranks of the military.

The downfall of this magnificent cordon of military and ecclesiastical establishments, and the return of the Indians to a savage life tenfold more ferocious than ever, is directly traceable to two causes. First, the revolution, where both the Monarchists and Republicans courted the co-operation of the Indians, and thus invited them to insubordination. Second, and more prominently, the attempts at amalgamation, by intermarriage of the whites and Indians.

This last cause, which is now operating so banefully over the whole of Spanish America, I do not think has been sufficiently estimated, in the attempts to account for the decline and retrograde march of the population of that entire region.

Wherever practical amalgamation of races of different color is carried to any extent, it is from the absence of the women of the cleaner colored race. The white makes his alliance with his darker partner for no other purpose than to satisfy a law of nature, or to acquire property, and when that is accomplished all affection ceases. Faithless to his vows, he passes from object to object with no other impulse than the gratification arising from novelty, ending at last in emasculation and disease, leaving no progeny at all; or if any, a very inferior and syphilitic race. Such are the favors extended to the white man by the lower and darker colored races,

that this must always be the course of events, and the process of absorption can never work any beneficial change. One of the inevitable results of intermarriage between races of different color is infidelity. The offspring have a constant tendency to go back to one or the other of the original stock; so that in a large family of children, where the parents are of a mixed race but yet of the same color, the children will be of every color, from dusky cinnamon to chalky white. This phenomenon, so easily explained without involving the fidelity of either party, nevertheless produces suspicion, followed by unhappiness, and ending in open adultery.

The only mode by which a country can be benefited by the introduction of the white race is by the introduction of both sexes, which, with proper guards upon morals, results in exterminating or crushing out the inferior races, or placing them in slavery.

Throughout Mexico, wherever the white race has preserved its integrity, there will be found a race of people very superior in both mental and physical ability; a condition due to the excellence of the climate, which combines all the qualities requisite for the development of the human being in the highest degree.

From Eagle Pass upwards there are no settlements on the American side, and but a single one on the Mexican side. In places are found the remains of settlements from which the inhabitants have been driven or carried off by the savages. This district of country, extending along the river seventy miles, until within five or ten miles of the mouth of the San Pedro, or Devil's river, is nevertheless the most fertile and desirable portion of the whole Rio Bravo for settlement. On the Texas side it is watered by the beautiful, limpid streams of Las Moras, Piedras Pintas, Zocaté, and San Felipe, which come into the Rio Bravo at right angles, and at equal intervals.

A very extensive region of land is here within the water-level, and can be successfully irrigated; and if we may judge from the products of the settlement at Santa Rosa, in nearly the same parallel, all the sub-tropical fruits and cereals can be raised in these bottom lands to advantage; while the uplands are clothed with a luxuriant growth of the most nutritious grasses. This country is unsurpassed in salubrity, and when the Indians are exterminated, and the adjacent mines shall receive their full development, it will be the paradise of Western Texas. Two causes will operate to postpone this to a very distant day: the proximity to the boundary, which affords so many facilities for the operations of banditti and horse-thieves; and the character of the country beyond, which will be seen, as you ascend the river, to be incapable of continuous settlement, and which must for a long time remain the hiding-place of the wild Indians.

One source of wealth in these table lands, and which is common to all the table lands contiguous to the Rio Bravo as far down as Reynosa, I have not yet pointed out; that is, the extensive growth of certain indigenous plants, the virtues and properties of which are well known to the Mexican and Indian population, and will be found elaborated and specifically noticed in the botanical memoirs appended.

On the mesas, or table lands, which are unsuited to the purposes of cultivation, many plants are found growing useful in medicine and dyeing; and various yuccas, dasylirions, and agaves, genera well known for their useful fibres, which we now import from foreign countries. There are also extensive growths of shrubs and trees of the leguminous order, furnishing gums, tannin, and nutritious pods, highly relished by the herbiferous animals, wild and domestic.

I have before stated that the present head of steam navigation is Roma. At some distant day, no doubt, the navigation will be extended up as high as the mouth of Devil's river,

a distance, measured by the sinuosities of the river, of 567 miles; and with this in view, the assistants in charge of the lineal surveys have been directed to make special notes of the obstructions in the river. The large maps designating the boundary, and deposited in the Department of the Interior, will form the basis upon which estimates for this purpose can be made, but they are too voluminous to accompany this printed report. The ideas now suggested are from the notes of assistant Arthur Schott, who was charged with the lineal surveys of the river from Devil's river to Ringgold Barracks, and from my own observations.

The navigation of the river between Edinburgh and Roma is not free from obstructions, but they are mostly of shifting sand-bars, except the one formed by Island 13 on the boundary map, which may be improved by damming two of the three channels. Between Roma and Bellville the obstructions are principally occasioned by Islands 15, 16, 17, and 20, dividing the channel of the river; and the navigation may be improved in the same way by damming all the channels but one, and dredging the bottom of the one left open. It is above Bellville that obstructions become of rocky character, difficult to remove, such as are to be found at Islands 25, 30, 31, 33, 35, 39; and above Loredo, at the Heron islands, Las Islitas, Cazneau island, and Chess-Board island.

The worst of these are Islands 25, 30, and the Islitas; 25 is sometimes called Major Brown's island, from the circumstance of the steamer Major Brown being detained there a whole season waiting for a rise of water; No. 30 is a couple of small islands, at the foot of which the channel is only eleven or twelve feet wide. Of the three last-named obstructions, the Islitas is the most formidable. Here, in fact, there is no channel, and the rocky islands obstructing the passage of the water can only be passed at high water from June to September.

Other obstructions besides islands are caused by numerous reefs and spurs of rock. Just above Bellville there is a formidable obstruction of this kind, marked by the wreck of the steamer "Exchange;" this obstruction is formed by two reefs running in from the opposite sides, and overreaching each other, thus leaving but a crooked channel, through which the river passes at the rate of five miles per hour. A similar obstacle occurs about fifteen miles below Eagle Pass.

Other reefs occur running entirely across the river, and are disposed in steps, one above the other. In seasons of excessive dryness they are bare of water. Of such character are the obstructions noted in the field-notes of Mr. Schott as "the snares," "the meshes," "the stone turtles," and the "Devil's pen," all situated between the Islitas and Eagle Pass.

In most cases the rocks forming the obstructions are sedimentary rocks of the upper cretaceous age, lying in horizontal strata; these would yield easily to the pick. How far it would be prudent to resort to cutting away these natural dams, as a mode of improving the navigation, which would necessarily lower the pools above, would be a subject of investigation for each locality. My object in this report is only to present a general view of the character of the difficulties in the way, and to present such maps as would render unnecessary any general survey of the river hereafter.

Except where interrupted by arroyos, the country is uniformly level, no hill breaking the general view until we reach Eagle Pass; and it may be that in time the resources of the country will be sufficient to justify its connexion by railroad with San Antonio or Brownsville, in which event the improvement of the navigation of the river will become of minor importance.

Ascending beyond the mouth of the San Pedro or Devil's river, the whole character of the

country changes. The bed of the river becomes hemmed in by rocky mural banks, the tops of which are beyond the reach of irrigation, and, from the aridity of the climate, they can never be made subservient to the purposes of agriculture. The general formation of the country is limestone, deposited in strata perfectly horizontal, and where the river has washed its way through the banks, presents the appearance of gigantic walls of dry-laid masonry. The course of the river from this point up to Fort Leaton, near the Presidio del Norte, a distance of 387 miles, is almost one continuous cañon, utterly unsuited to navigation, and with a few exceptions, unsuited for settlement. Occasionally this limestone formation, over 1,000 feet in depth, is broken through and upturned by igneous irruptions from below, forming stupendous mountains and gorges of frightful sublimity. I leave to the officers under my command, who so bravely surveyed these chasms heretofore untrodden by white men, and probably by Indians, the task of describing in detail this section of the work, which was only visited by me at certain places to determine the latitude and longitude.

My notices have been principally confined to the Texas side of the boundary. Before leaving the mouth of the Rio San Pedro to ascend the Rio Bravo, I will take a rapid view of the country on the Mexican side between this point and the Gulf. The most prominent topographical feature is a chain of lofty mountains of unequal elevation which cross the Rio Bravo about 250 miles above Rio San Pedro, and run in a southeasterly direction towards the Gulf. It is composed of a variety of ridges, preserving towards each other, and towards the river and the Gulf coast, a general parallelism. The principal range is called the Sierra Madre. The eastern slope of these mountains forms portions of the States of Coahuila, Nuevo Leon, and Tamaulipas. The area between the Rio Bravo and the bases of these slopes is an arid, cretaceous plain, covered with a spinose growth similar to that on the Texas side. Passing from this plain into the mountains, we encounter a soil made up of the debris of the older rocks, and watered profusely by limpid streams having their sources in the crystalline rocks. And here, in the valleys formed by these mountains, we find large tracts of country within the influence of some irrigating stream, sheltered from the northers of the winter, and at an elevation above the sea sufficient to overcome the excessive heat of the summer due this parallel of latitude, producing all the fruits of the tropics and the cereals of the more northern climates. The climate is unsurpassed in salubrity, and nothing is requisite to make this region the garden-spot of the valley of the Rio Bravo but a stable form of government and security from the bands of roaming savages that plunder it at intervals.

In the more northern portions, as at Parras, the vine is grown with success, and a luscious wine is made, which, however, will not bear transportation. On the seacoast and southern portion, commencing at Santa Rosa, oranges, limes, &c., are cultivated successfully. Some of the mountains are rich in silver, and at Santa Rosa, as has been elsewhere noticed, the mines were once extensively worked by the Spaniards, and have now passed into the hands of an American company.

In no civilized country are statistics more difficult to obtain than in Mexico, and several attempts to obtain the population of this region, composing the largest portion of the States of Nuevo Leon, Coahuila, and Tamaulipas, have resulted in such discrepancies as to induce me to give credit to none. I have, however, made an estimate of the resident population of the Rio Bravo on both sides, from the Devil's river down, which I here present. This estimate is rather under than over the number, which has heretofore been registered too high:

MILITARY COLONY, OPPOSITE FORT DUNCAN, TEXAS.

Eagle Pass	300
Piedras Negras	600
Loredo	700
Colonia Militar	50
Loredo Nuevo	700?
Mier	700
Roma	400
Guerero	600
Camargo	500
Rio Grande city	500
Reynosa	600
Brownsville	3,000
Matamoras	4,500
Burrita	300
Lomita	200
Rancherias at different points on the river	6,060
Total	20,210

Table of distances along the course of the river.

Names of places.	Distance between places.	Distance of each place from mouth of Rio Grande.
	Miles.	*Miles.*
Mouth of Rio Bravo		
Brownsville	49.81	49.81
Edinburgh	120.36	170.17
Ringgold Barracks	71.21	241.38
Roma	16.67	258.05
Bellville	45.93	303.98
Fort McIntosh	61.46	365.44
Falls of Presidio de Rio Grande	90.44	455.88
Fort Duncan	39.77	495.65
Mouth of Rio San Pedro	71.12	566.77
Mouth of Rio Pecos	41.48	608.25
Point where Lieut. Michler came to the Rio Bravo from San Antonio road	96.88	705.13
Point of beginning of Lieut. Michler's survey in 1853	49.05	754.18
Presidio de San Vincente	67.61	821.79
Presidio del Norte	132.00	953.79
Cañon on San Antonio road	222.78	1,175.57
San Ignacio	60.89	1,236.46
San Elceario	40.25	1,276.71
El Paso del Norte	25.38	1,302.09
Initial point of boundary where it leaves the Rio Bravo, running west	3.41	1,305.50
Frontera observatory	2.70	1,308.20

CHAPTER V.

FROM MOUTH OF DEVIL'S RIVER TO EL PASO DEL NORTE.

PECOS SPRINGS.—KING'S SPRINGS.—INDEPENDENCE CREEK.—RIO BRAVO INACCESSIBLE.—LIPANS.—CAÑONS AND RAPIDS.—MOUTH OF THE PECOS.—DEVIL'S RIVER.—DIFFICULTY OF NAVIGATION.—CAÑON OF BOFECILLOS.—COMANCHE PASS.—SAN CARLOS.—MOUNT CARMEL AND LOS CHISOS.—SAN VINCENTE.—PRESIDIO DEL NORTE.—VADO DE PIEDRAS.—TOWNS NEAR EL PASO.

The description of the boundary, up the river, is continued by the following reports of Lieutenant Michler and assistant Chandler:

WASHINGTON CITY, D. C., *March* 10, 1856.

SIR: The following is an extract of your orders to me, dated Washington City, D. C., April 4, 1853: "You are charged with the responsible duty of completing the unfinished portion of the survey of the Rio Grande, which forms the boundary between the United States and Mexico, between Fort Vincente and the mouth of the Rio Pecos."

Soon after their receipt the survey was commenced, and in the following August completed. Since then the maps have been finished, and several views of the scenery in the immediate locality of the work engraved.

I now have the honor of submitting a report of the manner in which the survey was conducted, and a description of that portion of the river, and the country adjacent.

Having organized a party, and made all preparations at San Antonio, Texas, we proceeded on the road to El Paso, and followed it as far as the Pecos Springs. At this place I determined to leave the road and strike for the Rio Grande, as directly as the nature of the country would permit. Owing to its character, and the necessity of taking wagons along, our route, as shown by the map, became somewhat circuitous. For the first fifty miles, from the Rio Pecos to King's Springs, the course was nearly due west, enabling us to avoid the many impassable arroyos setting in towards the former river. The road ran the greater part of this distance in small narrow valleys, gradually ascending towards their heads, passing from one into another, over high ridges, by precipitous ascents and descents. These valleys are bounded by chains of hills, either of a conical or oblong shape, the tops of which are on the same level and capped by horizontal layers of cretaceous limestone; the slopes are regular, well rounded, and steep. From the ridges, or high plains, which are generally very narrow, valleys ramify in every possible direction towards the Pecos. The grass is rich and luxuriant; low, scrubby bushes are found, but no growth of timber. No water, except what collects in the gullies during heavy rains, until you reach King's Springs. This is a large spring of water, deep and clear, with a fine gravel-bottom, and well protected from the sun by shelving rocks, but without bush or tree to mark its place. Whilst the main party encamped there, a reconnoissance was made in a so thwesterly direction for nearly sixty miles, when it was found impracticable to proceed

further. The course lay towards the "Los Chisos" mountains. The country is cut up by immense chasms, closed in by steep cliffs, unseen until standing upon the very edge of their fearful depths; rugged hills, covered with sharp igneous stones, make it difficult for animals to travel. The same volcanic formation as found along the Limpia extends over this section of country. The San Carmel range appears in the distance—high mountains, with their turreted peaks, could be seen, presenting a magnificent prospect like the spires of some distant city. Our efforts to travel in a southwesterly direction having proved unsuccessful, on leaving King's Springs we changed our route to a southeasterly one, and arrived at Independence creek. Along this distance of forty miles the country is of the same character as that first passed over. Whilst the train remained on the creek, a small party made examinations in advance. This is a beautiful stream, running boldly among the hills, and is fed by innumerable springs bursting out from its banks. It is a rich treat for the eye in that arid country. Besides a copious supply of fresh, clear water, there is more timber than is ordinarily found upon streams draining these high plains; mezquite trees grow in large numbers for miles around, and the valley furnishes luxuriant grazing for animals. This place is much frequented by Indians; an oasis in a desert country.

Numerous trails from the Pecos and the Escondido here unite and form a large broad one, running south to the Rio Grande; there are unmistakable signs of their constant use. Leaving the creek, we ascended the contiguous hills and rose upon a high plain, over which we travelled forty miles, following the guidance of the Indian trail; this was deeply marked, although it

Lipan Crossing—Eighty-five miles above the mouth of the Pecos.

is difficult to make an impression on the surface. It was a dreary sight to look upon the dull, wide waste around us; its parched barrenness, combined with the influence of a scorching July sun, was enough to madden the brain. The nearer we approached the river, the more rough the country became; deep ravines and gullies constantly impeded the progress of the wagons,

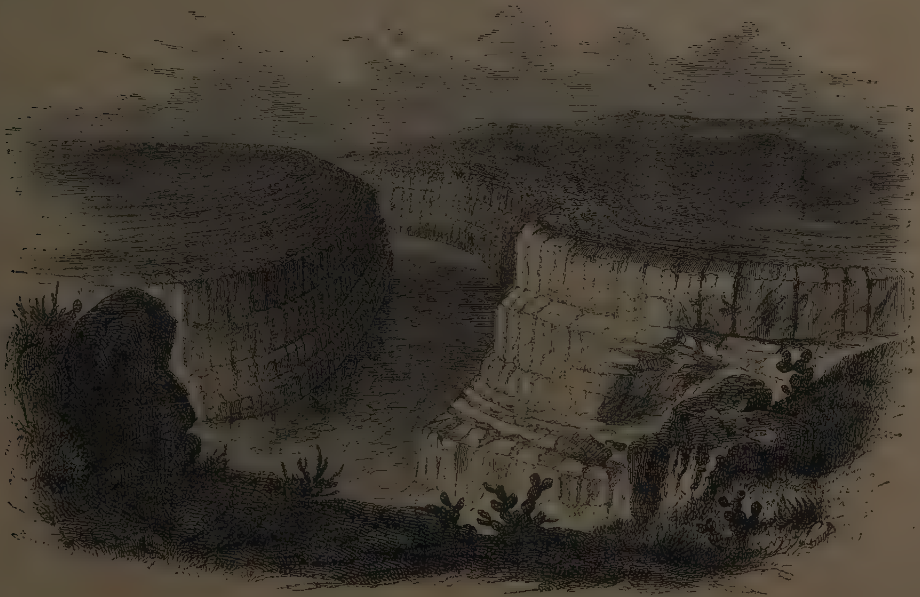
and the whole surface was covered with sharp angular stones and a growth of underbrush armed with thorns. Along this portion of the route, we found plenty of water in tanks at the heads of the ravines. There were, also, many fine springs. One in particular is noticeable for its beauty; falling over a precipice of forty feet, its waters were emptied into a large basin worn out of the solid rock. This was a favorite camping place of the Indians; the many paintings of men and animals found covering the rocks, testify to their rude attempts in the artistic line. The last ten miles kept gradually descending towards the river; occasionally the wagons had to be let down steep descents by means of ropes. Our road finally emerged upon a low flat plain about twenty feet above the level of the Rio Grande. We had, fortunately, struck the only place, as our examinations afterwards proved, where we could possibly reach the river with our wagons; the route was a circuitous one, in all 140 miles from the Pecos springs. The initial point of our work was found to be a little over forty miles above; the surveying party of the previous year had there suspended operations in consequence of the rugged character of the country, and had returned to Eagle Pass through Santa Rosa and San Fernando, Mexico. It was next to an impossibility to approach the river for the first twenty miles of the survey, this section being literally cut up by deep arroyos; steep hills, covered with rocks of igneous origin, intervene and jut into the water's edge. The river here is very tortuous. From the end of this section, the country undergoes a great change; the formation is limestone, and the river forces its way through a deep cañon nearly twenty miles in length, its banks being composed of

Lipan Crossing—View down the river.

high perpendicular masses of solid rock, resembling more the work of art than of nature. Arroyos of the same structure, at many places, open into the river; in following its course, we had frequently to make detours of twenty-five and thirty miles, in order to advance our work a few hundred feet. The plain where the main party encamped, and where we first struck the river, made a gradual descent to the water. Here was the first break in the cañon, and the

crossing being fordable, formed an accessible pass for the Indians into Mexico. This ford, known as the Lipan crossing, is represented by the preceding sketches.

The Lipans often visited us here, and made themselves useful as guides. As it proved to be impracticable to conduct the survey on land without taking an interminable length of time, it was decided to make the attempt in the bed of the river; anticipating such an emergency, boats had been built at San Antonio and brought along in wagons. After they had been put together and launched, and everything in readiness, the train was sent back by the road to Eagle Pass, there to meet the small party selected to descend the river to the same point. Upon trial, we found the boats, which were our only resource, would float—the only thing that could be said in their favor. The wood of which they were made was only partially seasoned, and the hot sun had so warped them, that they presented anything but a ship-shape appearance. The two skiffs were frail—a moderate blow would have knocked a hole in them—and the flat-boat was unwieldy and unmanageable. The current was so strong that two good oarsmen could not stem it in a light skiff. At the point of embarkation was a short break in the cañon of a few hundred feet on both sides of the river; the water then again rushed between rocky banks ten or twelve feet high, which increased in height as we proceeded. It would seem incredible that the bed of the stream could have been formed through ledges of solid rock, as shown in the accompanying sketch.



Cañon—One hundred and five miles above mouth of the Pecos.

The occurrence of a freshet whilst encamped on its banks, however, convinced me of the impetuosity of its waters, which appeared to force everything before them. The bed is narrow, and hemmed in by continuous and perfect walls of natural masonry, varying from 50 to 300 feet in height; the breadth of the river being extremely contracted, these structures, seen from our boats, look stupendous as they rise perpendicularly from the water. It is not unfrequently the case that we travel for miles without being able to find a spot on which to land. The limestone

formation is capped by an infinite number of hills, about 150 feet in height, and of every imaginable shape. The whole adjacent country is traversed by deep arroyos or cañons, intended by nature to drain the high plains bordering on the river; they are, in their appearance, but miniature creations of the same power which forced a passage for the Rio Grande. Their junctions with the river form large rapids or falls, caused by the rocks and earthy matter washed down them. These rapids are numerous, many of them dangerous, and will always prove insurmountable obstructions to future navigation. The force of the current is very great, and for thirty miles above the mouth of the Pecos is one continued rapid; its average rate is nearly six miles an hour. The width of the river varies from 80 to 300 feet, and at a few points narrows down to 25 and 30; when confined between its rocky walls the channel is very deep. There are no tributaries along this section of the work, but several fine springs contrast their clear blue with the muddy waters of the river. There is but little growth until the approach to the mouth of the Pecos; a narrow strip of soil is then occasionally found at the base of the rocks, and gives growth to some fine live-oak and mezquite trees; grape-vines flourish in abundance, yielding a very palatable fruit. Catfish were the only kind of fish caught, some of them very large and heavy. Soft-shell turtle

Junction of the Rio Bravo del Norte and the Pecos.

abound. But few varieties of game were seen; the wild turkey in large numbers, and some few deer—the latter of the black-tail species. The only practicable way of making the survey through the cañon was by allowing the boats to drop down the channel, taking the direction of the courses and timing the passage from bend to bend; when opportunity offered, the speed of each boat was ascertained by distances accurately measured on land, making allowances for change of current and other causes of error. Observations for time and latitude were taken every night to check the work. On arriving at the mouth of the Pecos, a view of which is given above, the survey, 125 miles in extent, was completed. The Pecos is more deserving of its other Mexican name, "Puerco," for it is truly a rolling mass of red mud, the water tasting like a mixture of

A. Schott. del.

Lith. of SARONY, MAJOR & KNAPP, N.Y.

LIPAN—WARRIOR.

every saline ingredient; its banks are like those of the Rio Grande for some distance above its mouth, and then become low and flat. As we continue to float down stream, we find the country below the junction undergoes some very considerable changes; these become still more apparent on reaching the San Pedro or Devil's river, whose waters form a dividing line between two distinct portions of country. The banks of the Rio Grande here present an entirely new appearance—they become low, and prairie land, covered with mezquite, extends as far as the eye can see; numerous well timbered and beautiful streams unite their waters with the river along this portion. Within a few hours of each other, both the party in charge of the train and the boat party reached Fort Duncan, near Eagle Pass, 110 miles by the river below the mouth of the Pecos.

View of Fort Duncan, near Eagle Pass.

To add to the interest of the expedition, a constant excitement was experienced in the descent of numerous falls. Ignorant of what unforeseen dangers awaited us, our frail boats were dashed blindly ahead by the force of a swift current over rocks and rapids, hemmed in on both sides by insurmountable walls which seemed mountain high, and at times not a spot upon which to rest a foot; there was but little chance of escape from destruction, letting alone the immediate peril of drowning in case of any accidents to the boats. Nor were these dangers imaginary—a serious accident, and one almost fatal to the success of the expedition and to the lives of most of the party, occurred the very first day after taking to the boats; notwithstanding every precaution had been taken, we were unable to avoid it, and our minds were most forcibly impressed with the truth that real dangers did exist. After having descended the river for a few miles an immense rapid presented itself to our view. The river here narrowed from nearly three hundred feet to the width of twenty-five; both shores could be touched with the ends of the oars; an immense bowlder divided the main into two smaller channels, leaving but a narrow chûte for the boats to descend. The bottom was covered with large rocks, and over these the

whole mass of water rushed, foaming and tumbling in a furious manner; a dangerous rapid was thus formed of several hundred feet in length, extending from bank to bank. The two skiffs made the descent in safety, although the waves rolled so high that each plunge filled them almost to overflowing. The flat-boat was not so fortunate; totally unmanageable, she ran square against the rocky walls, splintering and tearing away her entire front; such was the force of the blow that the crew were knocked flat on their backs, and the boat-hooks left firmly imbedded in the crevices of the rocks. Thrown back by the great swell, she commenced floating stern foremost down the rapid, gradually sinking. The men stuck to her faithfully, and the skiffs were put into immediate requisition; but by the expert swimming of two of the men, both Mexicans, who had dashed into the current ere the sound of the crash had died away, and seized her lines, she was landed on the end of a sand-bar which most providentially lay at the foot of the rapid; a few feet further, both men and boat would have been destroyed, and our all—provisions and ammunition—irrecoverably lost, the perpendicular banks offering no foothold where to land. With means at hand to repair the wreck, we were again afloat the following day, our craft bereft of all her fair proportions.

Before closing this report, I cannot refrain from informing you of the very able and willing assistance rendered me by my assistants, Messrs. E. A. Phillips and E. Ingraham, and Prof. Conrad Stremme; and of the patience and perseverance displayed by them and the men composing the party, under circumstances most peculiarly trying.

I am, sir, very respectfully, you obedient servant,

N. MICHLER,

Lieut. Corps Topographical Engineers, U. S. A.

Major W. H. Emory, U. S. A.,
U. S. Commissioner.

SAN VINCENTE TO PRESIDIO DEL NORTE.

Fort Duncan, *December* 1, 1852.

Sir: In accordance with your directions, I have the honor to make the following report on the topographical survey of that portion of the Rio Grande intrusted to my charge. The survey commenced a few miles above Fort Leaton, in the neighborhood of the Presidio del Norte, and extended to a point about one hundred and twenty-five miles above the mouth of the Rio Pecos, embracing a section of country which for ruggedness and wildness of scenery is perhaps unparalleled.

The appearance of the valley in the vicinity of Fort Leaton, with its succession of plains and arable bottoms, forms a contrast to the rugged country beyond. From this valley, which is from one to three miles wide on each side of the river, we suddenly enter the range of the Bofecillos mountains, through which the river has found or forced a passage, forming extensive rapids at its entrance.

A narrow path along the river on the American side is the only means of passage in the immediate vicinity of the stream; and numerous rocks and branches of trees obstruct even this narrow trail.

The cañon of the Bofecillos mountains is less rugged in its character than those met with subsequently. Although the passage of a mule train on the immediate borders of the river is utterly impossible, there is on the American side a valley extending nearly parallel to the course of the stream, at a distance varying from two thousand to three thousand feet; along this passes an extensive Indian trail, but to all appearances not recently used. Dangerous and long

Entrance to Cañon Bofecillos, Rio Bravo del Norte.

rapids occur where the river leaves the cañon, and the country loses entirely the features which characterize the north side of the Bofecillos range. The hills approach and recede from the river in varied succession; nearly always, however, admitting of the possibility of carrying the line of survey along the river bottom, at least as far as the Comanche Pass. Scarcely a tree or branch of the smallest size marks the hill-sides or summits, and it is only on the immediate border of the river that the eye, wearied by the continued succession of sterile plains, is relieved by the sight of verdure; and this only when the rocky barriers recede sufficiently for a narrow strip of soil to form.

Comanche Pass, on the Rio Bravo, the most celebrated and frequently used crossing place of the Indians, was found to be just below this Bofecillos range; here broad, well-beaten trails lead to the river from both sides. A band of Indians, under the well known chief Mano, (hand,) crossed the river at the time of our visit; they had come, by their own account, from the head-waters of Red river, and were on their way to Durango, in Mexico—no doubt on a thieving expedition.

At this pass the hills on either side are less elevated, and to the northwest the depression seems to extend many miles. Below the crossing the river passes through a country varying but little from that which was met with above. The San Carlos mountains rise in front to a considerable height. The strips of bottom land now become narrow, and occur at longer intervals.

The passage of the river through these mountains is grand and imposing. The entrance is shown in the accompanying sketch; dashing with a roaring sound over the rocks, the stream, when it reaches the cañon, suddenly becomes noiseless, and is diminished to a sixth of its former width; it enters the side of this vast mountain, which seems cut to its very base to afford a

Entrance to Cañon of San Carlos, Rio Bravo del Norte.

passage to the waters. On the right of the entrance, the rock is rounded and smoothed by the action of the water into an artificial appearance; on the opposite side the mountain receives the river in its full force. It is impossible to keep along the edge of the stream in its course through the mountain, and just as impossible to navigate it. The rapids and falls which occur in quick succession, make the descent in boats entirely impracticable.

A detour by San Carlos was rendered necessary, and the river was again reached at a point some twenty miles below the lower termination of the cañon. It is in the passage through these mountains that the well defined "rapids of the Rio Grande occur," which from their extent, and their near approach to a perpendicular line in their descent, merit the name of "falls." From the edge of the cañon the river may be seen far below, at a distance so great as to reduce it in appearance to a mere thread; and from this height the roar of the rapids and falls is scarcely perceptible.

It was impossible to approach them in consequence of the rugged nature of the country; the fall of the river at this point, however, may be estimated at twelve feet, without including the rapids above and below. The stream is hemmed in by the cañon for ten miles, and then leaves it with the same abruptness that marks its entrance.

It was here found necessary to cross the mule train from the Mexican side, where it had travelled since the commencement of the survey. This was effected, though with considerable difficulty, at one of the usual crossings of the Indians. Near this point, for some distance above

and below, the country is more open, the valleys broader, and are susceptible of cultivation; the bottom land is, however, limited by an elevated bank of gravel. There is also an abundance of cottonwood and mezquite timber.

Whenever the spectator was elevated sufficiently to see beyond the valley of the river, two prominent peaks were always presented to his view: one of these marks a summit in the range of the Mexican Sierra Carmel; and the other, from its peculiar shape and great height, was long and anxiously watched during the progress of our survey. From many places on the line it was taken as a prominent point on which to direct the instrument; and, though the face of the country might change during our progress down the river, still, unmistakable and unchangeable, far above the surrounding mountains, this peak reared its well known head. The windings of the river, and the progress of our survey, led us gradually nearer to this point of interest, and it was found to be a part of a cluster, rather than range, of mountains on the American side, known as "Los Chisos." For this peak, a view of which is here given, we have proposed the name of Mount Emory.

Mount Emory—Los Chisos mountains—Rio Bravo del Norte.

After passing this range of mountains, the survey was carried on with less labor than was previously encountered until we reached the Sierra San Vincente. Through these mountains the river forces its way, forming a cañon that equals the San Carlos in many places both in ruggedness and grandeur. A small party only could attempt the survey of this part of the line; and the command was divided, one party accompanying the mule train, and the other, under my personal charge, crossed the mountains. Here we experienced another series of falls or sharp rapids far down in the abyss along which the river finds its difficult course; the roaring of the waters announced a more than usual disturbance, and the boats soon encountered difficulties which, for one of them at least, were insurmountable. In this, as in other cañons, it was impossible to carry the line nearer the bed of the river than the summits of the

adjoining hills. Two days were necessary to overcome the obstructions of the passage through this cañon, from the top of which we thought we saw a comparatively smooth country extending nearly to the Sierra Carmel, the highest range of mountains seen on the Mexican side of the river. On a high mesa of gravel, some sixty feet above the level of the river bottom, is situated the old presidio of San Vincente, one of the ancient military posts that marked the Spanish rule in this country, long since abandoned; the adobe walls are crumbling to decay, and scarcely a stick of timber remains in the whole enclosure, except in that part devoted to the chapel. The line of survey was connected with this place at a point distinguished by a survey flag, and distinctly pointed out in a note left, in accordance with your orders, for Señor Salazar, of the Mexican Commission.

Continuing the survey from the Sierra de San Vincente, it was soon found that what in the distance seemed to be a smooth and open country was really rough and broken.

It proved to be a country cut up with deep arroyos, presenting to the survey almost insurmountable obstacles. Passing these arroyos, a wild valley, nearly at right angles with the course of the river, preceded the approach to the cañon of Sierra Carmel, another of those rocky dungeons in which the Rio Grande is for a time imprisoned. No description can give an idea of

Cañon below Sierra de Carmel.

the grandeur of the scenery through these mountains. There is no verdure to soften the bare and rugged view; no overhanging trees or green bushes to vary the scene from one of perfect desolation. Rocks are here piled one above another, over which it was with the greatest labor that we could work our way. The long detours necessarily made to gain but a short distance for the pack-train on the river were rapidly exhausting the strength of the animals, and the spirit of the whole party began to flag. The loss of the boats, with provisions and clothing, had reduced the men to the shortest rations, and their scanty wardrobes scarcely afforded enough covering for decency. The sharp rocks of the mountains had cut the shoes from their

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LIMPIA — WILD ROSE PASS

feet, and blood, in many instances, marked their progress through the day's work. Beyonp the Sierra Carmel the river seemed to pass through an almost interminable succession of mountains: cañon succeeded cañon; the valleys, which alone had afforded some slight chances foı rest and refreshment, had become so narrow and devoid of vegetation that it was quite a task to find grass sufficient for the mules. At a point some few miles below Sierra Carmel, it was supposed that a better pathway could be found on the Mexican side of the river. Just above the entrance of the river into a small cañon a place was chosen, which seemed to afford the most feasible opportunity for fording the river. With great difficulty the whole train was passed over without loss. With this slight interruption, the line of survey was carried on until it reached a point since shown to be about one hundred and twenty-five miles above the mouth of the Pecos. Here the work was suspended, owing to the failure of provisions and the means of transportation on the river. With the whole party we passed down on the Mexican side through the town of Santa Rosa, and arrived at Fort Duncan after a long and tedious journey. It is but proper, in justice to Messrs. Thompson and Phillips, the gentlemen associated with me as assistants, to mention their names as an expression of my appreciation of their exertions. To Mr. Phillips, for his able assistance and unvarying industry, I feel especially indebted.

I have forborne any but an incidental allusion to the difficulties of the survey under my charge, leaving it for yourself, so well acquainted with the character of the country gone over, to appreciate these difficulties, and thus excuse any deficiencies that may have occurred in the work.

I have the honor to be, very respectfully, your obedient servant,

M. T. W. CHANDLER,

Assistant in charge of party U. S. and Mexican Boundary Commission.

Major WM. H. EMORY,

Chief Astronomer and Surveyor U. S. and Mexican Boundary Commission.

PRESIDIO DEL NORTE.

We arrived in front of the Presidio del Norte July 8, 1852, and found watermelons ripe and the corn in tassel. The town, isolated and very remote from any other settlement, had been suffering from famine. The Indians had run off most of the cattle, and the drought for the three preceding years had caused a failure in the corn.

The Presidio is a miserably built mud town, situated upon a gravelly hill overlooking the junction of the Conchos and the Rio Bravo—the latter called here the Rio Puerco, no doubt from the contrast of its muddy waters with those of the Conchos, which, except during freshets, is limpid. The town, which contains about eight hundred souls, is one of the oldest Spanish settlements in northern Mexico; but from the barrenness of the soil, an attempt is making to settle a military colony forty miles higher up the Rio Bravo, where the land is supposed to be better adapted to agriculture.

The church is within the walls of the Presidio, or fort, and contains one or two paintings of a better class than are usually found disfiguring the walls of frontier churches. In almost every house is found, in addition to the cross, a figure of our Saviour, which is sometimes so very grotesque that piety itself cannot divest it of its ridiculous appearance.

These customs, however, are a source of comfort and happiness in prosperity and in adversity, in youth and in old age. They fill the imagination and give occupation to the idle, as the light literature of the day serves the more cultivated races. The padre who presides over the church in this district was by nature intended for the military profession. Brave, frank, handsome, and energetic, he is the leading spirit in every foray against the Indians, and is by no means an insignificant person in the trade of the place. He bears on his person more than one wound received in battle. In the present isolated and defenceless state of the Presidio, this gentleman is nevertheless as good a spiritual and temporal adviser as could be desired.

The relations between the Indians of this region and several of the Mexican towns, particularly San Carlos, a small town twenty miles below, are peculiar, and well worth the attention of both the United States and Mexican governments. The Apaches are usually at war with the people of both countries, but have friendly leagues with certain towns, where they trade and receive supplies of arms, ammunition, &c., for stolen mules. This is undoubtedly the case with the people of San Carlos, who also have amicable relations with the Comanches, who make San Carlos a depôt of arms in their annual excursions into Mexico. While at the Presidio we had authentic accounts of the unmolested march through Chihuahua, towards Durango, of four hundred Comanches under Bajo Sol. It seems that Chihuahua, not receiving the protection it was entitled to from the central government of Mexico, made an independent treaty with the Comanches, the practical effect of which was to aid and abet the Indians in their war upon Durango.

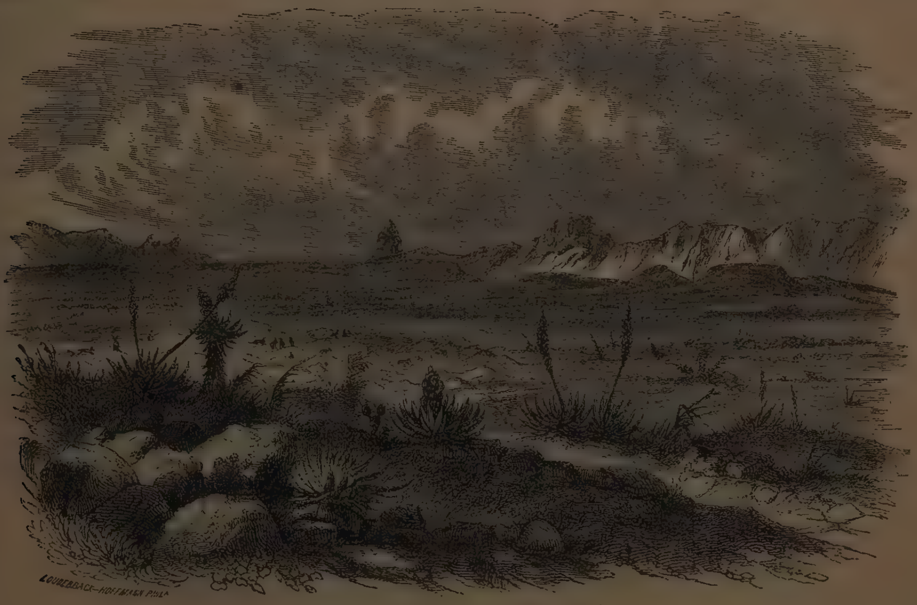
In the fall of 1851 I had the honor of entertaining at my camp the excellent and reverend Bishop Leamy, who was then on his return from a visit to the Bishop of Durango, to adjust the territorial limits of their respective dioceses to make them conform to the altered boundaries of New Mexico and Texas. He stated as his opinion, that the wealthy State of Durango must soon be depopulated by the Indians. Haciendas within a few leagues of the city, that once numbered one hundred thousand animals, are now abandoned.

This condition of things, together with the three years' drought, had overwhelmed the inhabitants of that State, and had driven them to unmanly despair. On the occasion of a great fiesta in the city of Durango, where no less than ten thousand people were assembled in and around the plaza, the cry was heard of Los Indios! Bajo Sol! and in a very short time every one had retreated to his house, leaving no one to face the enemy. The enemy, however, did not appear on the occasion, for it turned out to be a false alarm.

"Bajo Sol" is the title assumed by a bold Comanche, who, as his name signifies, claims to be master of everything under the sun. His name, which strikes dismay into every heart throughout Durango, is mentioned only in a whisper. I have never seen the villain or heard his name on the American side, where he probably takes another soubriquet; but I did meet one of his lieutenants, who, I have no doubt, was in all respects a worthy disciple. I give here a sketch of this rascal, by Mr. Schott: He called himself "Mucho Toro," and represented himself as a Comanche, but he was evidently an escaped Mexican peon. It was in the fall of 1851, in making a rapid march across the continent, escorted by only fifteen soldiers under Lieut. Washington, as we approached the Comanche springs after a long journey without water, that we discovered grazing near the spring quite one thousand animals, divided into three different squads. As we approached we could see with the naked eye a party of thirty or forty warriors drawn up on the hill overlooking the spring. I considered it inevitable to fight, or die with thirst; so, without making a halt, the men were deployed to the right and left of the wagons as light

infantry, and the whole moved rapidly towards the water. A flag was raised by the Indians, which was answered by Lieut. Washington and two others riding forward; but believing it a ruse to divide our forces, or give time to deliberate, I quickened the speed of the column, so as to keep Lieut. Washington under cover of our fire; so that we reached the ground and got within pistol-shot of the water before we halted to talk. A man was sent to the top of the hill with a spy-glass to look back, as if additional force was expected. We promptly corraled our wagons near the water, and put ourselves, without appearing to do so, in a good position to fight. We succeeded, without so stating, in producing the impression that we were only the advanced guard of a large force which would come on the next day, and possibly that night. We assumed all the air of the superior party, staid eighteen hours on the ground, and moved off the next day, as if we had a regiment to back us.

The party were Kioways and Comanches, returning from a foray into Mexico with nearly one thousand animals. "Mucho Toro," the chief of this party, who spoke Spanish well, stated he had purchased his animals in Mexico, and that he was but the advanced party of several hundred warriors, who were close behind him. We desired very much to attack the party, but our force was too small, and we were three hundred miles from support. The next day, when crossing the dividing ridge between the Comanche and Leon springs, we discovered the dust rising from the trail which crossed our road as far as the eye could reach, leaving no doubt of the truth of "Mucho Toro's" statement, that his was but the advanced party of "Bajo Sol's" four hundred men. The following summer we found that such a party had passed out of Mexico over this road.



View of Gomez Peak, from near Fort Davis.

"Mucho Toro" paid me a visit in full dress, on which occasion he displayed great humility, exhibiting conspicuously on his person an immense silver cross, which he stated had been given him by the Bishop of Durango when he was converted to Christianity. He had, no doubt,

robbed some church of it. His features showed the profile of the Mexican Indian peon, but the warriors he commanded had the bold aquiline profile of the Kioways and Comanches. I present him as a type of that class of Mexicans who, by affiliation with the wild Indians, have produced such irreparable ruin to the northern States of Mexico.

We heard of many such parties, and encountered many adventures similar to that just narrated, but I shall not trouble the reader with any reference to these rascals, or our adventures with them, except to say that I never trusted them; and during the last year of my experience with them I gave orders to permit none to come into any camp under my orders, and to kill them at sight. By taking this harsh but necessary step, I was the only person passing through this country who did not incur difficulty and loss. The Mexican commission was robbed repeatedly, and on more than one occasion was, in consequence, obliged to suspend its operations.

The Rio Bravo, accommodating itself to the geological formation of the country, makes, between the 100th and the 104th meridian of longitude, two great bends nearly symmetrical, one to the south and the other to the north. The area included in the southern bend is one vast cretaceous bed, upheaved by igneous protrusions, sometimes forming ranges of mountains, as the Limpia range, and at others isolated peaks, like Gomez Peak and San Jacinto. To the east and north of the Leon springs the limestone beds are in repose, and do not appear disturbed until we get to Las Moras.

It is, generally speaking, very destitute of water, and the excess of lime in long continued droughts often destroys vegetation. There are, however, oases of surpassing beauty, such as that described in Lieutenant Michler's journal. There is another on the road which I opened

Site of Fort Davis—Limpia Mountains.

from the Presidio del Norte to the Leon springs, called the Puerto del Paisano. This is a valley on the northern slope of the principal range of the Limpia mountains, watered by a limpid stream from crystalline rocks, clothed with luxuriant grass, sufficient to graze a million of

Arthur Schott del.,

Lith of Sarony & Co New York

TORO - MUCHO.

CHIEF OF A BAND OF KIOWAYS.

cattle. On the hill-tops overlooking the valley, live oak and pine grow in abundance, but are much distorted and wind-shaken, and generally unfit for building purposes.

This road, which will be found traced on the map, was opened for the double purpose of communicating with my parties on the lower Rio Grande, and of shortening the distance from San Antonio to Chihuahua. The route followed by the merchant trains is by the way of El Paso, a distance greater by 300 miles. It is possible a shorter route may be found, but our explorations led us to believe this was the shortest one where a permanent supply of water could be obtained.

Fort Davis has been established since our survey. There is now a constantly travelled road connecting Fort Davis and Chihuahua, via Presidio del Norte.

Several other roads have been opened through this region—one other by myself, one by Colonel Johnston, and one by Lieutenant Michler; all having for their object a more direct communication with the lower Rio Bravo. A good wagon road is said to exist along the Comanche trail, figured on the map, but this I doubt.

The area included in the southern bend forms of itself a distinct drainage, and is one of those basins peculiar to the interior of the continent. It is called by the Mexicans the Bolson de Mapimi, and its waters run into the Lake Jaqui, the rendezvous and stronghold of the Comanches and Kioways, who annually plunder Durango and the neighboring States of Mexico. It is here they collect and divide the plunder, consisting of women, children, and animals. Here, also, they leave their rifles, depending alone upon the lance in their depredations upon the Mexicans.

The immediate neighborhood of the Presidio del Norte, situated in the southern bend above described, is very dry, owing, I think, in some measure, to the manner in which the mountains recede from the valley at that point. The summer we passed there, clouds, discharging water and electricity copiously, were almost daily seen following the ranges of mountains, about ten miles to the south, while not a drop fell upon the Presidio for some weeks. Indeed, so great were the rains to the south, that the Conchos was swollen, and about the 10th of August the whole valley of the Rio Bravo, below its junction, was inundated. This is said to occur annually.

There is sometimes an overflow in June, from the melting of the snows at the head of the Rio Bravo, and it is to these two overflows that the country is indebted for the little capacity it possesses for agricultural pursuits. A narrow belt of alluvial soil is moistened, upon which corn and vegetables are raised.

For a description of the valley of the river from the Presidio del Norte to the cañon, where the San Antonio and El Paso road first strikes it, I give an extract from the official report of assistant von Hippel:

"From Presidio del Norte to Vado de Piedras, a distance of twenty-four miles, the valley of the Rio Bravo has a course from southeast to northwest, and is from three to four miles in width. It is a good grazing country, and the soil is of easy cultivation. This valley is enclosed by hills on the American side, and on the Mexican side by a large mountain range.

"Vado de Piedras is a Mexican military colony, containing some three hundred persons. Here are large cultivated fields, which are watered by acequias, and yield abundant crops of wheat and corn. The place takes its name from the rocky ford of the river opposite the town, which is quite shallow at the ordinary stage of the water.

"Here the river takes a course nearly north, through a valley, varying in width from one-half to one and a half miles, till it comes to Pilaris, forty-five miles from Vado de Piedras. Pilaris was once a military colony, and, from abundant signs still visible, the smelting of silver ore was carried on extensively. It has long been deserted, and I could not learn from what mountains in the vicinity the ore was procured. The river continues the same general course through a valley, bounded by high ridges of mountains, for some eighteen miles, when it enters a large cañon of six miles in length. On emerging from this it changes its course to northwest, through an open valley of eight miles in length, the bearing of which is north and south.

"It now passes between low hills for some eight miles, when it breaks through an immense mountain range, where its banks are of perpendicular rock, of from four to five hundred feet in height. In this cañon are many rapids, and one fall of some six feet, making navigation impossible, except at a very high stage of water.

"One mile above the cañon, on the American side, is a level plateau of rock, about one-half mile square, near the centre of which are two warm springs, their cavities having a funnel-shape, and of great depth. The temperature of the water in them is about 180° Fahrenheit. From these springs the river continues a northwest course, through a narrow valley, for twenty-four miles, to the cañon where the San Antonio road leaves it."

From the cañon up to El Paso, a distance of eighty or ninety miles, the valley of the river will average from six to ten miles in width, and is, almost everywhere within the water-level of the river, capable of cultivation. On the American side, however, there is no settlement

Socorro, Texas.

until within a few miles of San Elceario, a distance of sixty miles from the cañon. On the Mexican side there are two small military colonies—Guadalupe and San Ignacio—of about five hundred inhabitants each. From San Elceario up to El Paso, a distance by the sinuosities of

the river of thirty miles, but by air-line of only twenty miles, is almost one continuous settlement of Mexicans and Pueblo Indians, with here and there an American farmer or trader. I estimate the whole population of the valley as follows:

El Paso	4,000
Franklin	200
Socorro	300
San Elceario	1,200
Guadalupe	800
San Ignacio	500
Total	7,000

I have included under the head of El Paso the Indian town of Sinecu, which is in the eastern part of the settlement, and is stated to have been built by the aborigines, before the occupation of the country by the Spaniards.

There are some families of pure Spanish descent in this valley, but the population is generally of a mixed character—a cross of the Indian and Spaniard. They are mostly engaged in agriculture and commerce. Before the ports on the lower Rio Bravo were opened, there was sometimes as much as two million dollars' worth of goods passed into the northern States of Mexico by the way of El Paso; at present, I suppose there is not more than $500,000 or $1,000,000, and of import about $70,000. The grapes, peaches, figs, melons, and the fruits generally of this valley, are of very superior quality. There are two descriptions of grapes—one white, the other large and blue; both are very luscious, having no trace of the musky taste of American grapes, and in skilful hands make delicious wine and good brandy. When I first visited New Mexico, in 1846, that whole country was supplied with wine and brandy from El Paso. It is now mostly consumed in the country, or sent to Chihuahua. The wine as at present made will not bear transportation, and as a general rule is but an imperfect test of what the grape can produce. The town of El Paso is itself but one extended vineyard in the hands of many proprietors. The culture of the grape, and its product of wine, would be much increased but for the difficulty of procuring vessels in which to place it for transportation. There is no wood in that whole region from which casks can be manufactured, and there is not yet sufficient demand to authorize the erection of founderies for making glass bottles.

The meteorological table which I have given in the general sketch is not a fair exhibit of the hygrometric character of this region; that record was kept in the last year of the great drought, which extended through 1849–'50–'51. In the succeeding years much more rain fell, but I had no party stationary at any one point, and therefore the record of 1851 was given as that which extended over the greatest space.

In the summer of 1852 the rains were frequent and copious. While occupied at the cañon, in the astronomical determination of that station, a deluge occurred which will long be remembered by those present.

In the middle of the night of June 25, the sky was overcast and our labors at the observatory obstructed. We had all retired to bed, when I was awakened by a roaring noise, which I supposed to be wind. I called to Mr. Burns, who was in charge of my zenith telescope, to take the usual precautions against high wind. He answered that it was not wind, but water; adding, if we did not leave camp pretty soon we should all be drowned. I had made the selection of my camp on a spot which I supposed secure from any possible inundation, but on

stepping out of my blankets, found myself knee-deep in water, which was rapidly rising. My first impulse was to seize the chronometer and note-books of the survey, and make for the small eminence upon which the observatory was placed. Only two persons were near enough to assist me, Mr. Gardner and my cock, and neither of them could swim. As we advanced, the water came up to the chin, and the soft ground under foot gave way. It was with the greatest difficulty we reached the hill with our precious load. The night was inky dark, but I caused fires to be built, when all hands immediately went to work, and by the time day broke we had secured nearly everything of value. The only public property lost was some belonging to the escort, composed of raw recruits, many of whom could not speak a word of English, and who, in the absence of their commanding officer, took to the hills, and could not be brought down till day-light. A tremendous rain on the adjacent mountain had fallen during the early part of the night, and the accumulated waters finding insufficient drainage, made for themselves a new channel, which unfortunately passed through our camp.

Throughout that whole region traces of the same kind of deluges can be found, where for months and years not a particle of running water is ever seen. These traces receive the name of arroyos, and I think may be taken generally as evidences of a country subject to long droughts, only interrupted at long intervals by heavy falls of rain.

On a more recent visit to El Paso, in the summer of 1855, the rains were very frequent and heavy. On one occasion several adobe houses were washed down, and, with few exceptions, every house in the place was damaged and rendered leaky. This town, although built in the sixteenth century, and possessing a very considerable trade, does not contain a single stone, brick, or wooden building. The houses, of one story, are built of adobe, (mud and straw,) and the tops covered with tile, grass, or mud, supported by undressed cottonwood logs. They resemble very much the ruins of the houses described in the oases of Syria, and particularly in the dimensions of the rooms, which are accommodated to the rude carpentry of semi-civilized nations. However long a room may be, it is never more than twenty or thirty feet wide, the span of a stick of timber, without the aid of king-posts.

Drawn by A. de Vaudricourt — Lith. of SARONY MAJOR & KNAPP New York

THE PLAZA AND CHURCH OF EL PASO.

CHAPTER VI.

SKETCH OF TERRITORY ACQUIRED BY TREATY OF DECEMBER 30, 1853.

AREA.—HOW WATERED.—FACE OF THE COUNTRY.—PLAYAS.—VALLEYS AND THEIR CAPACITY FOR AGRICULTURE.—ABANDONED SETTLEMENTS.—MINERAL WEALTH.—PIMOS INDIANS.—DESCRIPTION OF SKETCHES.—VIEWS.

The territory acquired under the treaty of December 30, 1853, lies between the parallels of 31° 20′ and 33° 30′, and between the meridians of 106° 30′ and 104° of longitude measured from Greenwich, and contains 26,185 square miles.

Its eastern part is bounded by the Rio Bravo; its northern by the Rio Gila. The interior of the area is traversed by two rivers, which run northwest and empty into the Gila. These are the San Pedro and the Santa Cruz.

A smaller rivulet, lying to the east of both of these, called the San Domingo, takes its rise near the middle of the territory and runs in a northwest direction, emptying into the Gila. This last named river, like the Santa Cruz, is of uncertain flow, and in dry seasons only stands in pools, or is found running under ground, making it necessary for the traveller or grazier to dig for water. There are numerous springs scattered about in the mountains which dot this area, but as they do not usually occur in the levels or mesas, it is somewhat difficult to reach them.

The mountains which traverse this territory run mostly in the same general direction as the river—that is so say, northwest and southeast. The most remarkable feature in the mountain system of this region, is that the elevations are mostly isolated, and have received the local designation of "Lone Mountains," so that a traveller passing from the Rio Bravo to the Pimo villages may, by deflecting slightly from a straight line, pass most of the way over a mesa, the different planes of which vary but slightly in elevation, and are usually from 3,000 to 4,000 feet above the sea.

It is that peculiarity which gives this territory a leading interest as affording a practicable passage for a national railway to the Pacific, and the facility of making a military road over easy gradients to unite the posts in the valley of the Rio Bravo with those on the Gila and in California.

These levels, although usually covered with a luxuriant growth of nutritious grasses, are mostly destitute of water; hence, the traveller is now obliged to seek his road over a more rugged surface in the mountains, where water is to be found. These levels, however, are the recipients of the drainage of the surrounding mountains, and water can be had by sinking wells at no great depth below the surface.

South of the Picacho de los Mimbres the Rio Mimbres, which is a large lively stream in the mountains, disappears entirely in its course to the south, in a large open plain, which presents to the eye of the distant observer the appearance of a meadow.

West as far as 112° meridian of longitude, the soil of the levels and hills is everywhere good, and, except in the playas, covered with a luxuriant growth of nutritious grass, mostly the grama.

The playas are large flats where water accumulates, and salts deleterious to vegetation are disengaged from the soil. They are not, however, very extensive, nor do they occur very often.

West of the 112th meridian, the soil becomes very sandy; the mountains of igneous rocks are bare of vegetation, and as we approach the Gulf of California, except in the immediate beds of the Gila and Colorado, the country becomes a hopeless desert—destitute alike of both water and vegetation—and from the best information I can collect, this is the character of the eastern coast of the Gulf of California as far down as the island of Tiburon, (almost to Mazatlan.) Of this particular section the memoir of Lieutenant Michler, which follows this, will give a more detailed description.

It is very possible the whole of the new territory, except the region of desert country referred to above, may be brought under the influence of artesian wells and made productive; but until that is the case, agriculture must be confined to the beds of the river, where the land is below the water-level. There are many tracts of this kind of surpassing richness, but of limited extent, on the Rio Bravo, on the Rio Gila, on the San Pedro, and on the Santa Cruz. Those which are most conspicuous, and which are at present in a very advanced state of cultivation, are the Mesilla Valley on the Rio Bravo, the Valleys of Tucson and Tomacacori on the Santa Cruz, and the settlement of the Pimos on the Gila river.

Throughout the whole course of the San Pedro there are beautiful valleys susceptible of irrigation, and capable of producing large crops of wheat, corn, cotton, and grapes; and there are on this river the remains of large settlements which have been destroyed by the hostile Indians, the most conspicuous of which are the mining town of San Pedro and the town of San Cruz Viejo. There are also to be found here, in the remains of spacious corrals, and in the numerous wild cattle and horses which still are seen in this country, the evidences of its immense capacity as a grazing country.

Removed from the river-beds, at the base of the mountains, where perpetual springs are found, are also to be seen the remains of large grazing establishments; the most famous of which is the ranch of San Bernardino, which falls half in the United States and half in Mexico. I have been informed that this establishment was owned in Mexico, and when in its most flourishing condition boasted as many as one hundred thousand head of cattle and horses. They have been killed or run off by the Indians, and the spacious buildings of adobe which accommodated the employés of this vast grazing farm are now washed nearly level with the earth.

Wherever water is sufficient, this whole region presents marvellous advantages for the raising of stock, owing to the character and quantity of the grass, the mildness of the winters, and its almost perfect exemption from flies and mosquitoes.

MINERAL WEALTH.

Retaining a vivid recollection of the constantly threatened desertion of our work in California, and the inconveniences which sometimes actually occurred, growing out of the gold mania which raged there in 1849, just as we were commencing to run the line, I kept the search for gold and other precious metals as much out of view as possible, scarcely allowing it to be the subject of conversation, much less of actual search; for I well knew if this mania was once to seize my party, it would be attended with the worst consequences; consequently, our investigations into the mineral wealth of the region have not been as thorough as they otherwise would have been.

Enough was ascertained, however, to convince us that the whole region was teeming with the precious metals. We everywhere saw the remains of mining operations, conducted by the

Spaniards, and more recently by the Mexicans. At this moment several companies from California are prospecting with success, and one company is working a mine in the Sierra del Ajo, west of Tucson. There are the remains of mines in the Mimbres mountains, rich in copper and gold; in the San Pedro mountains, between the San Pedro and Santa Cruz rivers, and on the Santa Cruz river a few miles north of the boundary, there are the remains of a mill for crushing gold quartz. These came under my own observation; and we had many reports of mines to the north, and invitations to visit them, which it was inconvenient to accept. We had what I consider authentic accounts of silver being found in *placers* in the Ajo mountains a little north of the line; although I have never before heard or read of silver being found in placers. I was informed upon authority which I could not permit myself to doubt, that a solid lump of virgin silver had been picked up in that region weighing eighteen ounces. Gold had been found in placers in the new territory in small quantities, in the Mimbres mountains, in the Chirricahui, and in the hills bordering the Santa Cruz river, between the boundary and the Calabasas ranch; and quite a rich placer is found in the mountains to the south of the line near Cocospera. Argentiferous galena, iron ore and meteoric iron are found in several localities. The analysis of Dr. Easter which is appended to this report will give the values of such of the metals as are collected.

I hope nothing I may say will induce persons to run off in unprofitable searches in these distant and unprotected regions. To guard against this it may be well to state, the country is now full of *prospecters* from California, who will undoubtedly discover anything worth knowing.

There are causes which must operate against the speedy development of the mineral wealth of this country, no matter how rich it may prove. One is the hostility of the Indians, which makes it unsafe for parties of less than fifteen or twenty to traverse the country; another is its remoteness from navigation and the scarcity of water.

There are within this territory four settlements; one the Mesilla Valley settlement, containing about fifteen hundred inhabitants of the mixed Spanish and Indian races, all engaged in the pursuit of agriculture.

At Tucson there is a settlement consisting of about seventy families, engaged in the same way. South of Tucson there is a small settlement at San Xavier of semi-civilized Indians, called Papagos; and further on, at Tomacacori, a small settlement of Germans.

San Xavier was once a Jesuit mission, and there remains in a very good state of preservation a large and handsome church.

The most considerable and interesting settlement in the new territory is composed of a confederacy of semi-civilized Indians, the Pimos and Coco Maricopas. Their population is variously estimated at from five to ten thousand. The military commandant at Santa Cruz estimated the number of warriors which they could muster at two thousand. They are located on the Gila river, and form the most efficient barrier for the people of Sonora against the incursions of the savages who inhabit the mountains to the north of the Gila, and who sometimes extend their incursions as far south as Hermosilla, in the State of Sonora.

I became acquainted with these people in 1846, and in another work eulogized their advanced state of civilization, their proficiency in agriculture and the art of war, and their morality. While at Los Nogales, our last astronomical station near the 111th meridian of longitude, a delegation, consisting of the chiefs and head-men, visited my camp, nearly two hundred miles distant from their homes, to consult as to the effect upon them and their interests of the treaty with Mexico, by which they were transferred to the jurisdiction of the United States. I give below a copy of the statement made at the meeting, where it will be seen I said all in my power

to silence their apprehensions. They have undoubtedly a just claim to their lands, and if dispossessed will make a war on the frontier of a very serious character.

I hope the subject will soon attract the attention of Congress, as it has done that of the Executive, and that some legislation will be effected securing these people in their rights. They have always been kind and hospitable to emigrants passing from the old United States to California, supplying them freely, and at moderate prices, with wheat, corn, melons, and cotton blankets of their own manufacture.

CAMP AT LOS NOGALES, *June* 29, 1855.

Capt. Antonio Azul, head chief of the Pimos; Capt. Francisco Luke, Coco Maricopa chief; Capt. Malai, Coco Maricopa chief; Capt. Shalan, a chief of Gila Pimos; Capt. Ojo de Burro, war-chief of Pimos; Capt. Tabaquero, a chief of Gila Pimos; Capt. La Boca de Queja, a chief of Gila Pimos; Capt. José Victoriano Lucas, head chief of San Xavier Pimos; Capt. José Antonio, chief of San Xavier Pimos, have this day visited my camp for the purpose of ascertaining in what manner the cession of the territory, under the treaty with Mexico, will affect their rights and interests. I have informed them that, by the terms of the treaty, all the rights that they possessed under Mexico are guarantied to them by the United States; a title to lands that was good under the Mexican government is good under the United States government. I informed them that, in the course of five or ten months, perhaps sooner, the authorities of the United States would come into the ceded territory and relieve the Mexican authorities; until that time, they must obey the Mexican authorities, and co-operate with them, as they have done heretofore, in defending the territory against the savage Apaches.

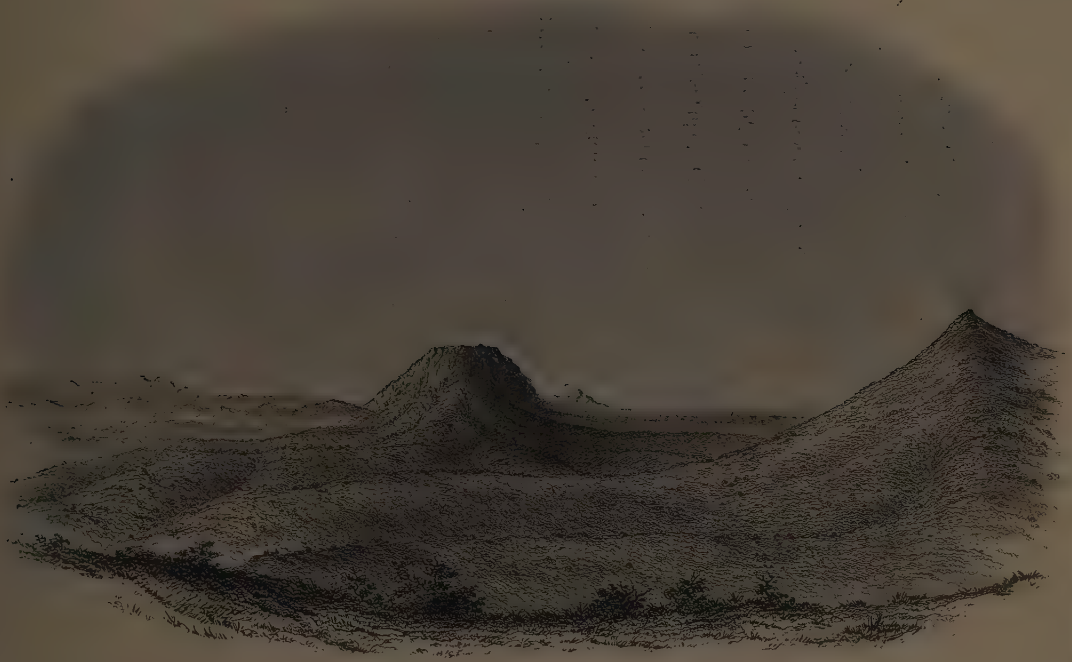
I have examined the testimonials given by numerous American emigrants to Azul and his captains, bearing testimony to the kindness and hospitality of himself, and the Pimo and Coco Maricopa Indians generally. I can myself bear testimony to the truth of these statements. I therefore call upon all good American citizens to respect the authority of Azul and his chiefs.

W. H. EMORY,
U. S. Commissioner, Major U. S. A.

ANTONIO AZUL,	*alias*	CHE-T-A-CA-MOOSE.
FRANCISCO LUKE,	"	SEE-COOL-MAT-HAIS.
MALAI.		
SHALAN,	"	KI-MAH.
OJO DE BURRO,	"	WAH-LA-WHOOP-KA.
TABAQUERO,	"	VIR-AH-KA-TA.
LA BOCA DE QUEJA,	"	KI-HO-CHIN-KO.
JOSÉ VICTORIANO LUCAS.		
JOSÉ ANTONIO.		

I furnished the head-chief a copy of this paper and gave him for distribution among his subalterns, some silver dollars, and all the blankets and cloths which could be spared from our camp.

I conclude this chapter by giving a series of views along the line, sketched by Mr. John E. Weyss. These views commence at the point where the boundary line leaves the Rio Bravo, and terminate at the 111th meridian of longitude. They were taken to perpetuate the evidences of the location of the boundary, in the event of the Indians removing the monuments erected on the ground. They give also a very good idea of the topography of the country.



VIEW OF MONUMENT MOUNTAIN

NOTES TO ACCOMPANY SKETCHES, (VIEWS ALONG THE BOUNDARY LINE ON PARALLEL 31° 47′ AND 31° 20′ NORTH LATITUDE), BY JOHN E. WEYSS, FROM STARTING POINT ON THE RIO BRAVO TO 111TH MERIDIAN OF LONGITUDE.

Sketch No. 1 presents a view of the initial point on the Rio Grande, the observer looking west along the line, parallel 31° 47′ N. The flag indicates the point where the line crosses the mountain known as the "Muleras." Directly west of this mountain, the line crosses a very sandy valley, supposed to be a former bed of the Rio Grande, and strikes the table land (some 200 feet above the river) about three miles from the initial point. Here sketches Nos. 2 and 3 were taken, looking respectively east and west.

Sketch No. 2 is a back view, looking towards the initial point, again showing where the line crosses the Muleras mountain, and also, in the back-ground, the mountains near Franklin, east of the river.

Sketch No. 3 is a view taken at the same point as No. 2 ; that is, where the line first strikes the table-land, but in the direction of the line westward. The line here leads over an apparently endless level table-land, which is very sandy and generally without grass, but thickly covered with clumps of bushes and small sand-hills four or five feet high. On the horizon, exactly in the line, is visible the top of an isolated mountain, serving beautifully as a natural monument. The mountains seen on the right hand are the "Sierra del Potrillo."

Sketch No. 4 is taken from the top of the isolated mountain that the line strikes, as represented in sketch No. 3. By this view, the observer looks east along the line towards the initial point. The volcanic mountain range on the left of the flag is called "Sierra Seca." The two mountains behind this Sierra are the topmost peaks of the Sierra del Potrillo, represented in sketch No. 3. The Sierra, quite on the back-ground, shows the mountains near Franklin, and those on the right of the flag are the mountains near El Paso.

Sketch No. 5 is a near view of the Monument mountain before mentioned, on which is shown, by the flag, the exact point struck by the boundary line. This view was taken from a point west of this mountain, and about a mile from it.

Sketch No. 6 is a view also taken near, and from the west side of Monument mountain, but looking westward along the line. At this mountain the table-land ceases, and the line passes over a series of hills for about 2.5 miles, the highest of which is not more than 300 feet, with so gentle an ascent as to be easily crossed with loaded wagons. Passing these hills, the line leads into a broad valley, bounded on the west by the Sierra del Carrizalillo. About a mile from the foot of these hills the sand begins to disappear, and fertile soil takes its place. The pasturage of this valley was everywhere luxuriant ; and in its lowest part, nearly midway between Monument mountain and the Sierra del Carrizalillo, about one mile south of the boundary line, are the "ojos adjuntos," the first permanent water near the line west of the Rio Grande, and about sixty-four miles from the initial point. The "ojos adjuntos" are a series of lagoons formed by many springs, of which fifteen were counted, all affording clear water. They are connected, and all together present a sheet of water from one and a half to two miles long, by from one-third to one-half mile broad, and four to five feet deep ; their direction is north and south. The most northern springs, as also the lagoons which they form, are some four or five feet higher than the surrounding prairie. It is possible that these springs are but the re-appearance of the Rio Mimbres. Fine grama grass surround these lagoons and springs, but no bushes. From the "ojos adjuntos" to

the foot of the Carrizalillo hills, there is a gentle ascent of the prairie. In the prolongation of the line towards this last named Sierra, it passes six miles south of the "Sierra del Tabaco," and north of, but very near, two small isolated hills, where the magnetic needle underwent a variation of 2° 30′; the needle was affected by this magnetic influence at the distance of three miles, on each side of these hills. The mountains on the left of the flag in this view, are the Sierra de la Boca Grande; those directly on the back-ground, the Sierra del Carrizalillo, where the line crosses; and those on the right hand belong to the Sierra del Tabaco.

Sketch No. 7 gives a view of the Carrizalillo hills where they are crossed by the line. It leads up a steep valley across these hills, through an open valley, into another series of hills, where the parallel 31° 47′ terminates. This termination is marked by a monument, a view of which is given in sketch No. 8.

Sketch No. 8.—From this point southward the meridians connecting the parallels 31° 47′ and 31° 20′ constitute the boundary line. This sketch gives a view westward, from the terminal point of line on parallel 31° 47′, and not along the line.

Sketch No. 9 represents a view of the line, on the meridian, from the monument marking the terminal point on parallel 31° 47′. The flag marks the direction across the hills.

Sketch No. 10 is taken from the point where the flag stands in sketch No. 9. This view is south along the meridian. The high mountains on the left are the Sierra de la Boca Grande. The distant hill ranges beyond the plain, and covered by the flag are the hills on which is erected the monument marking the beginning of the boundary on parallel 31° 20′. The hills on the right hand belong to those adjoining "Ojo del Perro." The boundary line here runs through a large valley or plain; the Sierra de la Boca Grande lying on the east, and the Sierra de la Hacha, and that of Ojo del Perro, on the west. Nearly in the middle of this valley, and about 172 miles east of the boundary line, are situated the Ojos de los Mosquitos, five in number, which, though furnishing an abundant supply of clear water, soon sink below the surface. The pasturage of this valley is good in some places; but the soil is generally sandy, and many spots are destitute of vegetation. As the mountains are approached, the soil becomes gravelly and bushes abound.

Sketch No. 11 presents a view of the hills on which is located the monument marking the initial point of the line on parallel 31° 20′. The view looks south along the meridian, and the flag marks the spot where the monument is erected.

Sketch No. 12 is a back view from the monument, looking north along the meridian. The rocky bluffs on the left are a part of the mountains near Ojo del Perro. Further on, and in the middle ground, are seen the Sierra de la Hacha, and entirely in the back-ground appear the hill ranges on which terminates the line on parallel 31° 47′.

Sketch No. 13 is taken from the same point as No. 12, but looks west along the parallel 31° 20′. All the hills here represented belong to the Sierra del Ojo del Perro. The spring giving name to the sierra is situated at the foot of the second mountain on the right of the flag, and is about seven miles west of the monument, and north of the flag one and a half.

Sketch No. 14 is a view taken from the place marked by the flag in sketch No. 13, looking eastward. The range behind the flag embraces the hill on which is located the monument, as shown in sketch No. 13. The mountain range in the back-ground on the left is Sierra de la Boca Grande. From this flag westward the boundary line runs for a few miles over a series of round hills, and, after crossing a wide valley, strikes the high Sierra de San Luis. The soil of this valley is light and sandy, except in the middle it is covered with grass and other vegetation.

It contains a large prairie-dog town, and, constituting the receptacle of an extensive drainage, would be passed with much difficulty during the rainy season. A series of springs were discovered near the middle of the valley, and about one mile south of the line. They form a little creek, but are lost in the sand in a run of less than two miles.

Sketch No. 15.—A near view of the San Luis mountains where they are crossed by the line; sketched from the intersection of the line and the road leading from Janos to Santa Cruz.

Sketch No. 16.—This view is sketched from the monument near San Luis springs, looking eastward. The flag shows where the line crosses the mountain.

Sketch No. 17 is taken from the same point as No. 16, but in the opposite direction. The top of the mountain on the back-ground, directly over the monument, is the first over which the line runs near the Guadalupe Pass.

Sketch No. 18 is a near view of the mountain whose top rests on the horizon in sketch No. 17. The flag indicates where it is struck by the line.

Sketch No. 19 looks west along the line, and is taken from the point marked by the flag in No. 18.

Sketch No. 20 is drawn from the point indicated by flag in No. 19. It looks westward, and the single peak in the back-ground belongs to the mountain ridge west of San Bernardino; and the sierras still further off are the San José and Éspinola, on the left and right, respectively.

Sketch No. 21 is a view looking eastward from the point where the line crosses the road through the Guadalupe Pass.

Sketch No. 22 is a view from the monument near the springs of San Bernardino, looking west along the boundary, and giving a nearer view of the peak seen from the Guadalupe cañon, and represented in sketch No. 20.

Sketch No. 23.—A back view taken from the same point as No. 22, but looking eastward towards the Guadalupe cañon.

Sketch No. 24.—In this the observer again looks west, and is shown where the line crosses the first mountain-ridge west of San Bernardino. The mountain on the left of the flag is the peak referred to in sketches Nos. 20 and 22.

Sketch No. 25.—This view is sketched from the point indicated by the flag in Sketch No. 24. The high mountain on the left fore-ground represents the before-mentioned peak. The high sierra in the back-ground on the flag is the San José; that on the right the Sierra de Éspinola. Rain-water was found at the foot of the hill where the flag stands, and was the only water near the line between San Bernardino and Rio San Pedro, a distance of fifty-five miles. The Rio San Pedro flows along the eastern base of the Sierra de Éspinola.

Sketch No. 26 is a view taken at the foot of the hill on which the flag stands in sketch No. 25; it looks west along the parallel. From this hill, as far as the banks of the Rio San Pedro, the line runs over a rolling prairie of a light, sandy soil, sometimes covered with bushes, sometimes bare, and fine patches of pasturage occurring here and there.

Sketch No. 27.—View looking west along the line from from flag-staff in sketch No. 26.

Sketch No. 28.—Sketched from flag in view No. 27, also looking westward. The mountains on the left edge of which the flag rests, and marks the line, are the Sierra de Éspinola.

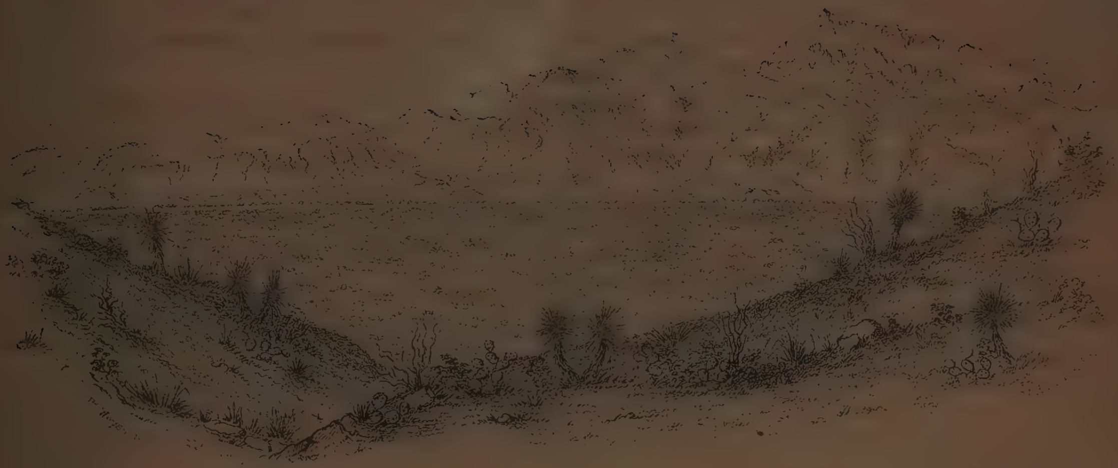
Sketch No. 29.—This view looks westward, and is taken on the east bank of the Rio San Pedro, where it is crossed by the line. At this point, approaching from the east, the traveller

comes within a mile of the river before any indications of a stream are apparent. Its bed is marked by trees and bushes, but it is some sixty or one hundred feet below the prairie, and the descent is made by a succession of terraces. Though affording no very great quantity of water, this river is backed up into a series of large pools by beaver-dams, and is full of fishes. West of the river there are no steep banks or terraces, the prairie presenting a gentle ascent. Here again the flag represents where the line touches the Sierra de Éspinola. The mountains in the back-ground on the left of the flag are directly east of Santa Cruz.

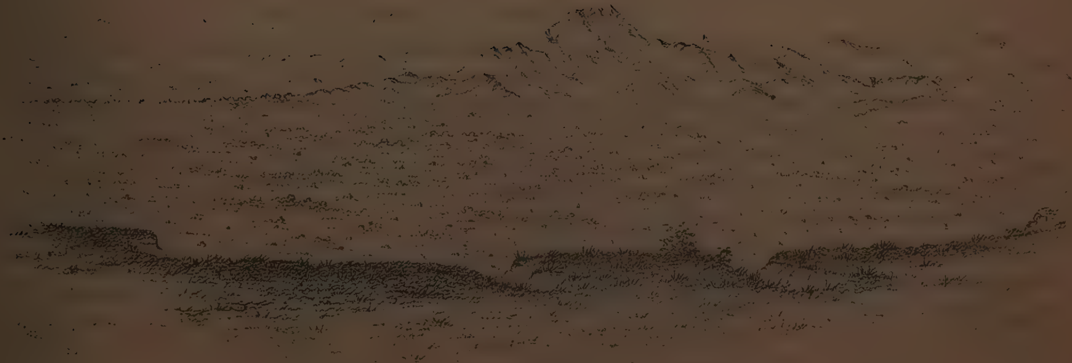
Sketch No. 30 is taken from the monument situated north of Santa Cruz, and is a back view, showing the flag on Sierra de Éspinola.

Sketch No. 31.—A view from the same monument, but looking westward. The mountains in the right-hand corner of the back-ground are the Santa Rita.

Sketch No. 32.—This is a view near Los Nogales, and shows where the line crosses the road leading from Tucson to Imuris. It looks south from the monument. The mountains in the back-ground are called the Sierra del Pajarito.

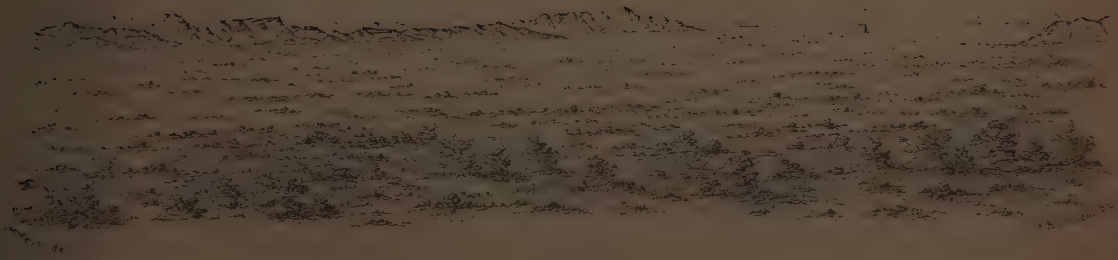


VIEW OF THE INITIAL POINT OF THE BOUNDARY LINE ON THE RIO BRAVO DEL NORTE - LOOKING WEST

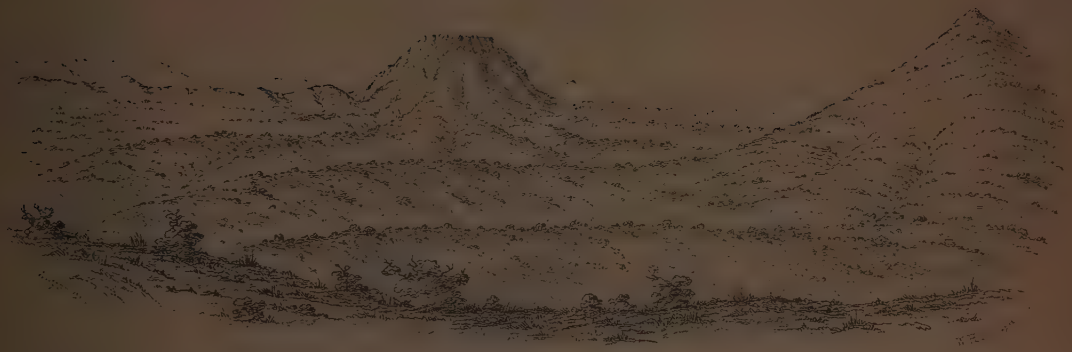


VIEW ALONG THE BOUNDARY LINE - LOOKING EAST FROM MONUMENT Nº 3 ON PARALLEL 31°47'

... M MONUMENT N ... [illegible]

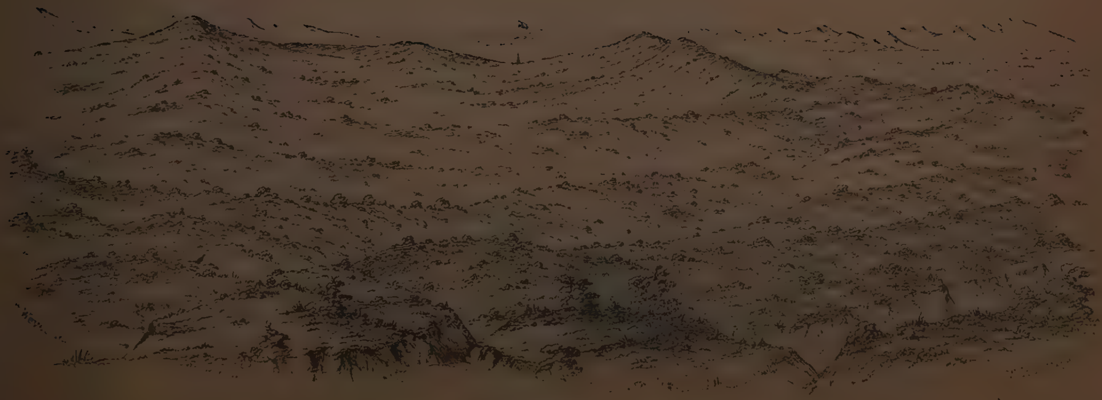


VIEW FROM MONUMENT Nº 4—LOOKING EAST ALONG THE PARALLEL OF 31° 47'



VIEW FROM MONUMENT N° 5 LOOKING [illegible]

6



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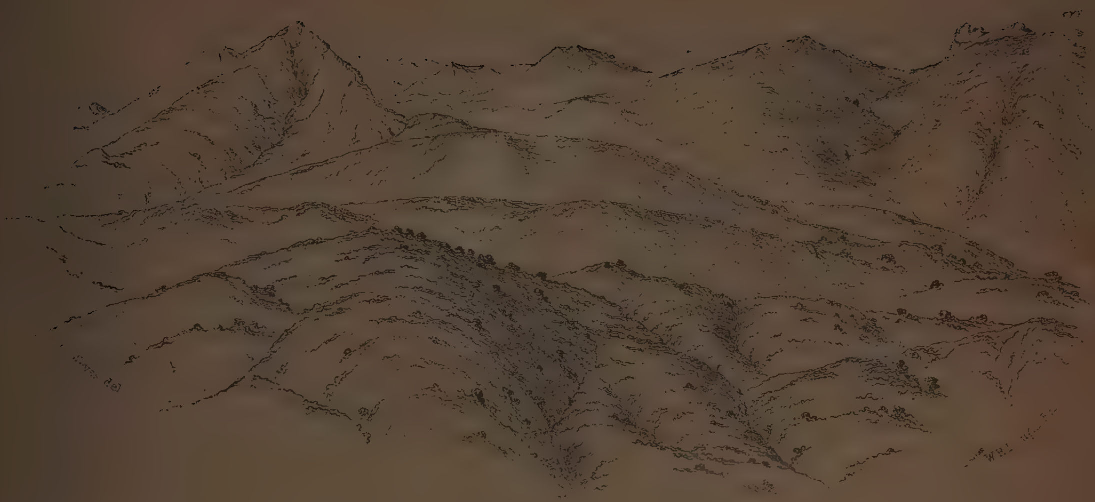
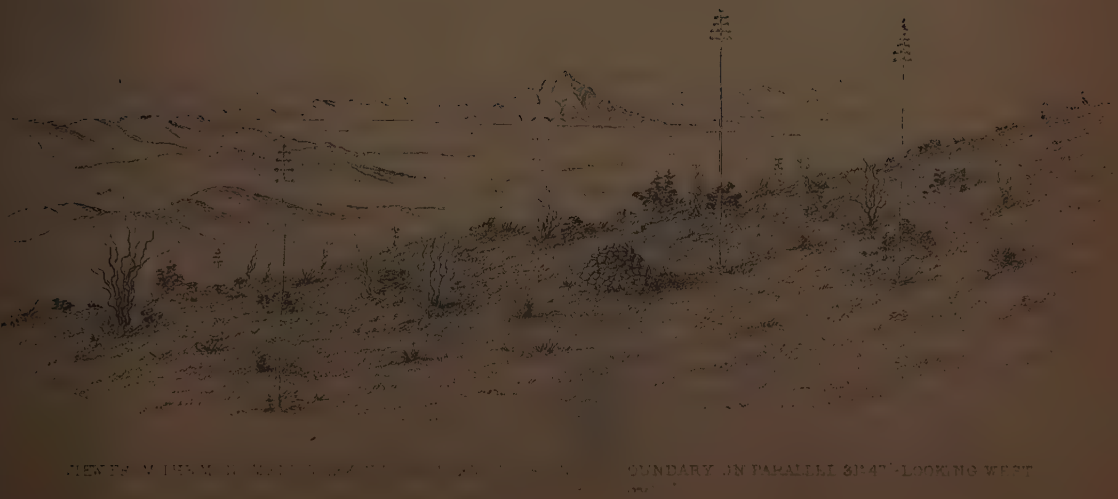
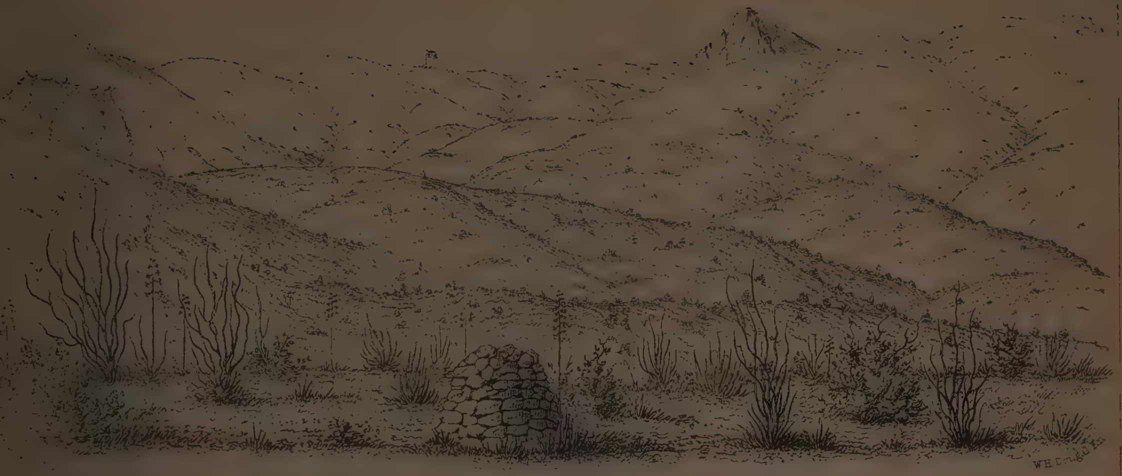


VIEW OF THE CARRIZALILLO HILLS WHERE CROSSED BY THE BOUNDARY LINE ON PARALLEL 31°47′ LOOKING WEST

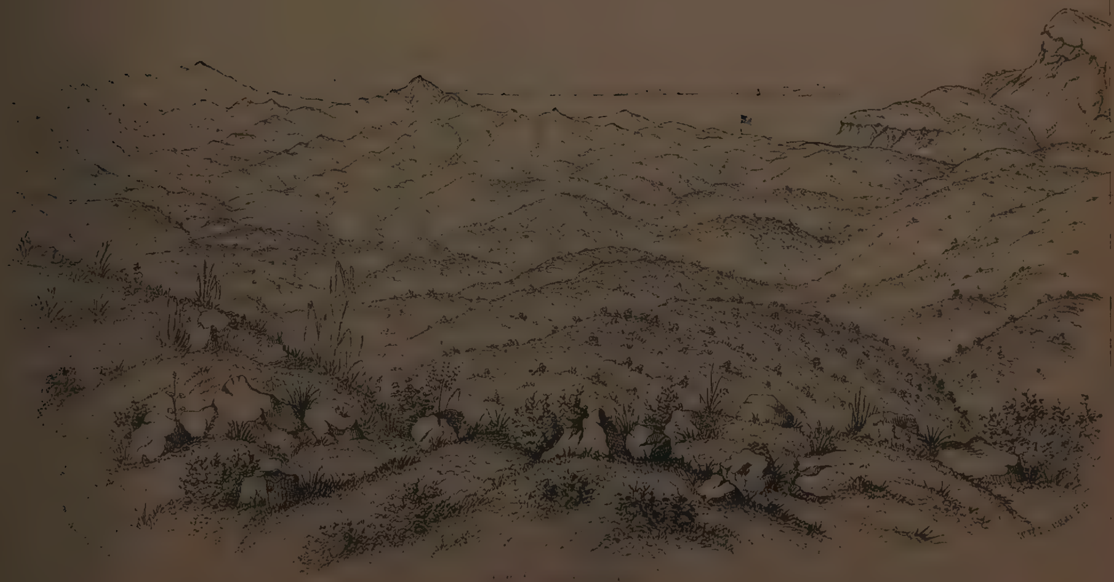


[illegible] BOUNDARY ON PARALLEL 31°47′—LOOKING WEST

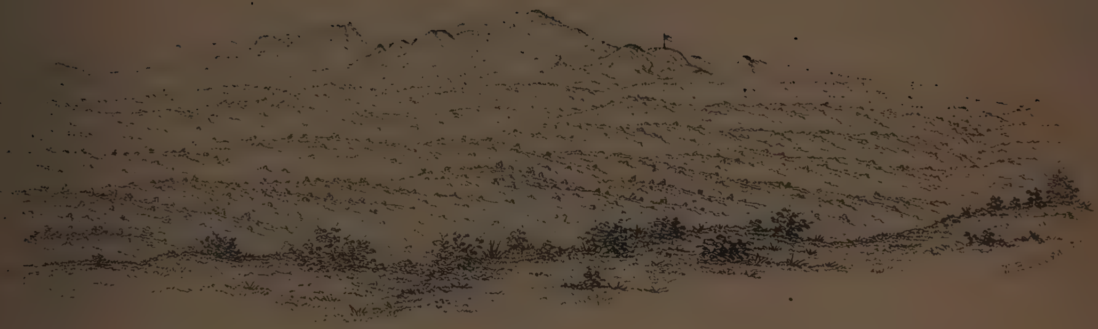


VIEW FROM THE MONUMENT MARKING THE TERMINAL POINT OF BOUNDARY ON PARALLEL 31° 47′ – LOOKING SOUTH.
ALONG THE MERIDIAN

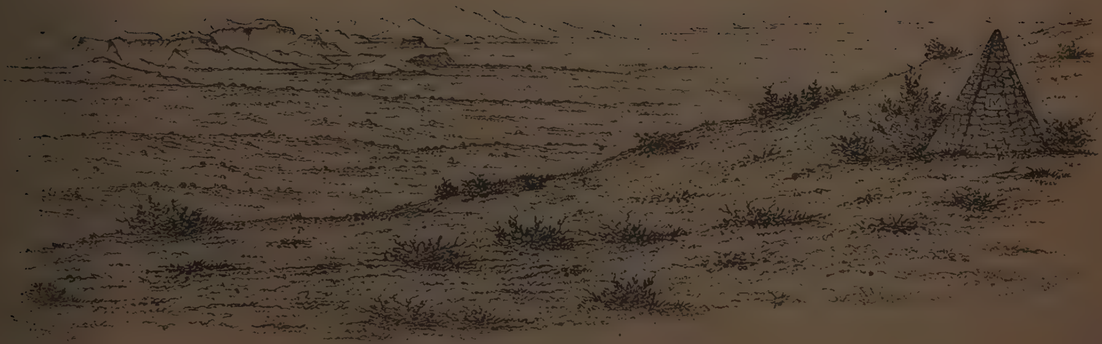
10



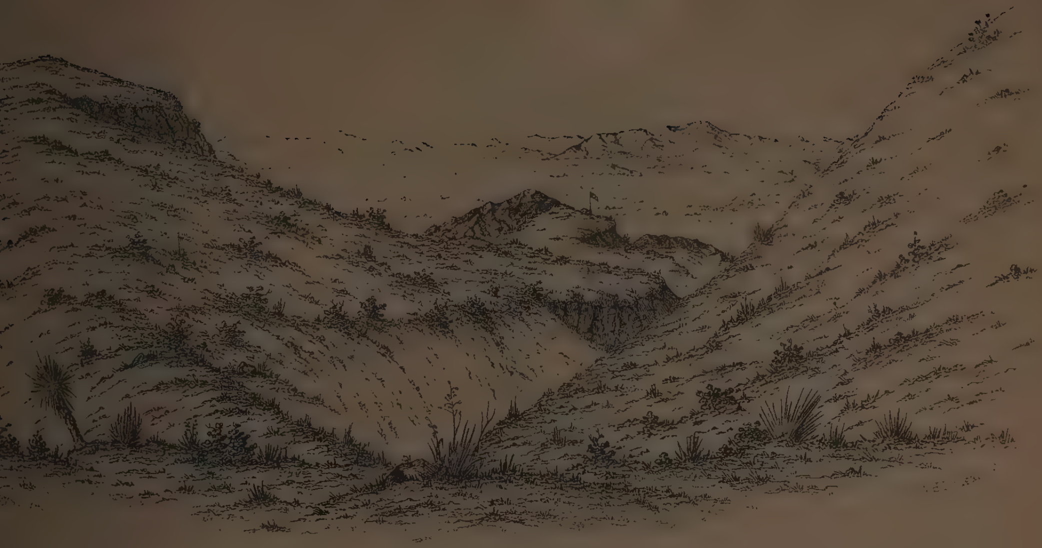
DISTANT VIEW OF THE HILLS ON WHICH IS LOCATED THE MONUMENT MARKING THE INITIAL POINT
OF THE BOUNDARY LINE ON PARALLEL 31° 20′–LOOKING SOUTH
ALONG THE MERIDIAN



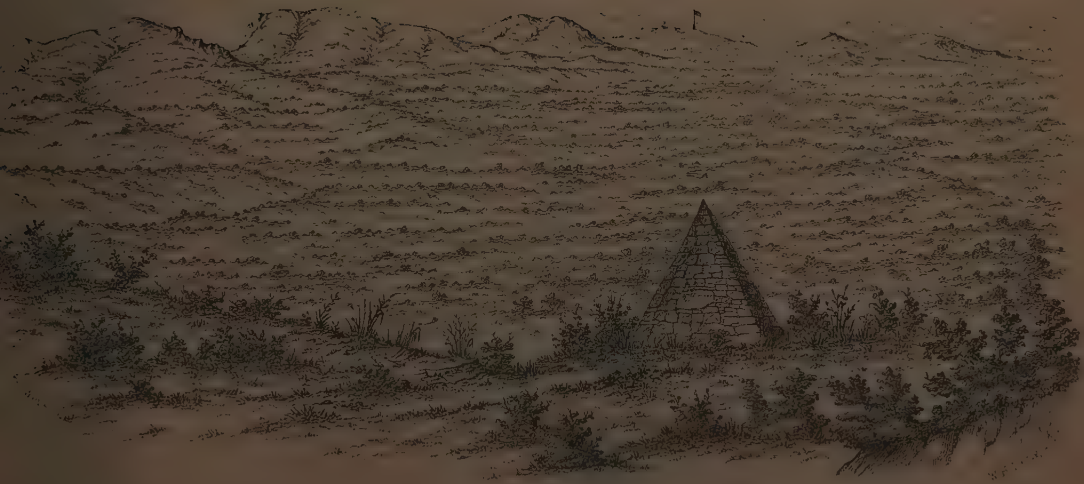
NEAR VIEW OF THE INITIAL POINT OF THE BOUNDARY LINE ON PARALLEL 31°20 LOOKING SOUTH ALONG THE MERIDIAN



VIEW FROM INITIAL POINT OF BOUNDARY LINE ON PARALLEL 31°20 LOOKING NORTH ALONG THE MERIDIAN



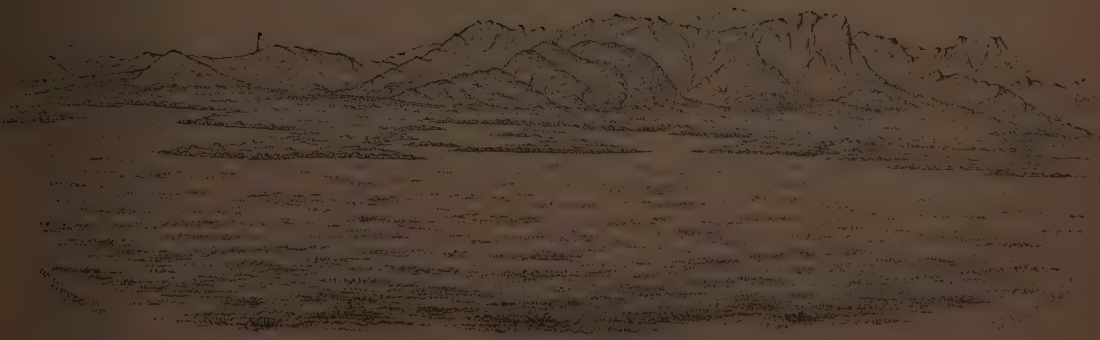
VIEW FROM HILL RANGE REFERRED TO IN Nº 13 BACK TO INTERSECTION



... ECTION OF MERIDIAN AND PARALLEL OF 30°20 - LOOKING WEST ALONG THE PARALLEL TO THE FIRST RANGE OF HILLS

VIEW ALONG PARALLEL 31° 20 FROM MONUMENT ON THE JANOS ROAD TO THE POINT WHERE THE LINE CROSSES ST LOUIS MTS

16

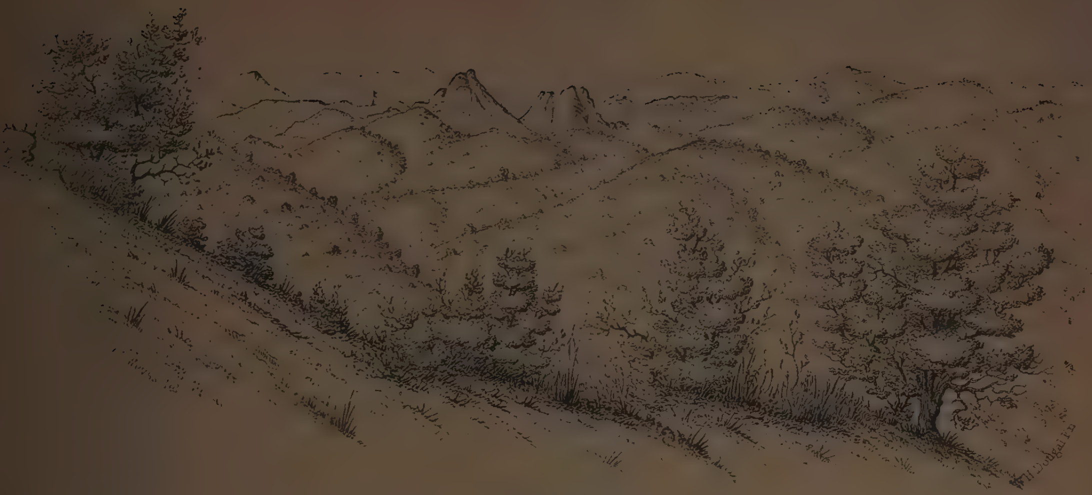


VIEW FROM EMORY'S MONUMENT SOUTH OF ST LUIS SPRINGS BACK TO THE SAME POINT ON THE MOUNTAINS

17

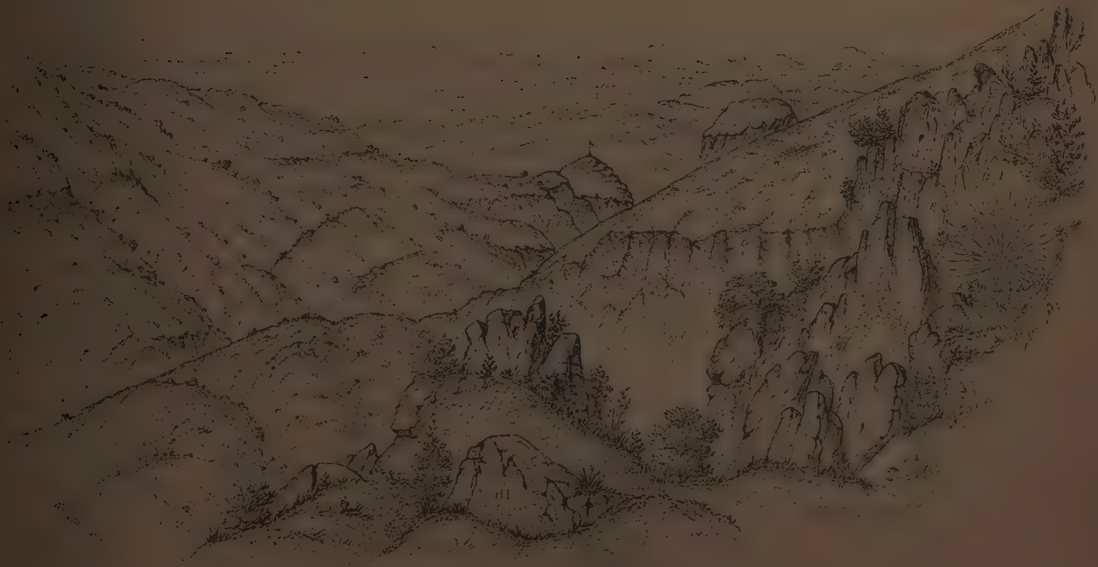
VIEW FROM EMORY'S MONUMENT SOUTH OF THE SAN LUIS SPRINGS LOOKING WEST ALONG THE PARALLEL OF 31°20

18



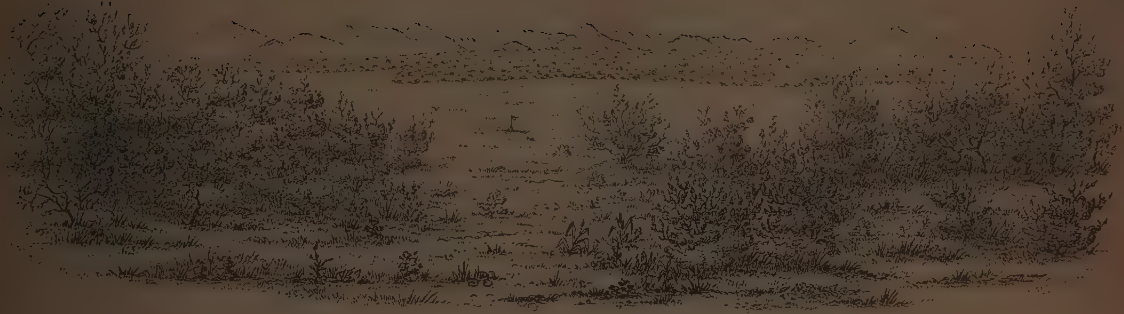
FIRST VIEW OF THE GUADALUPE CAÑON ALONG THE BOUNDARY LINE ON PARALLEL 31° 20'–LOOKING WEST

20



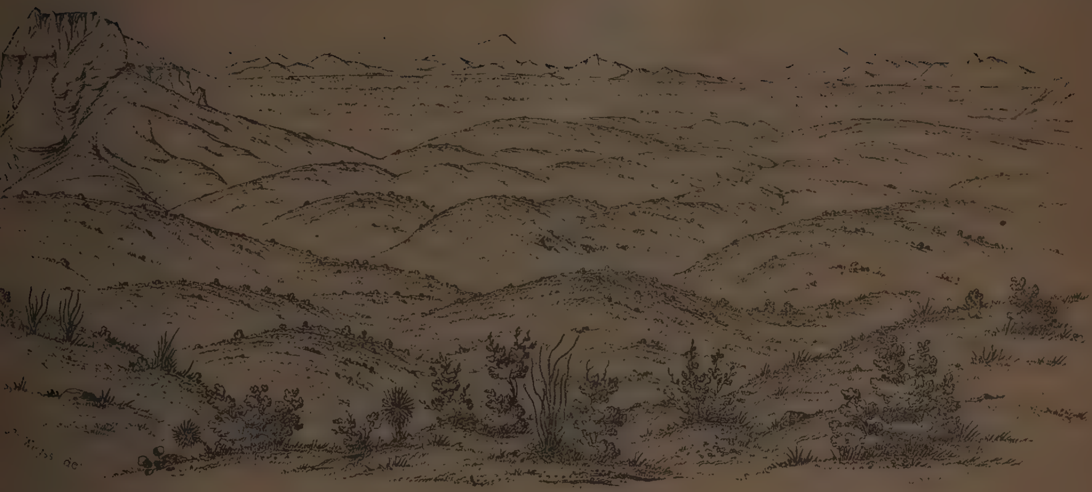
VIEW OF THE POINT WHERE THE LINE CROSSES THE ROAD IN THE GUADALUPE CANON LOOKING EAST ALONG THE PARALLEL 31°20'

EMORY'S MONUMENT AT THE SAN BERNARDINO SPRINGS-LOOKING WEST ALONG THE PARALLEL OF 31°20

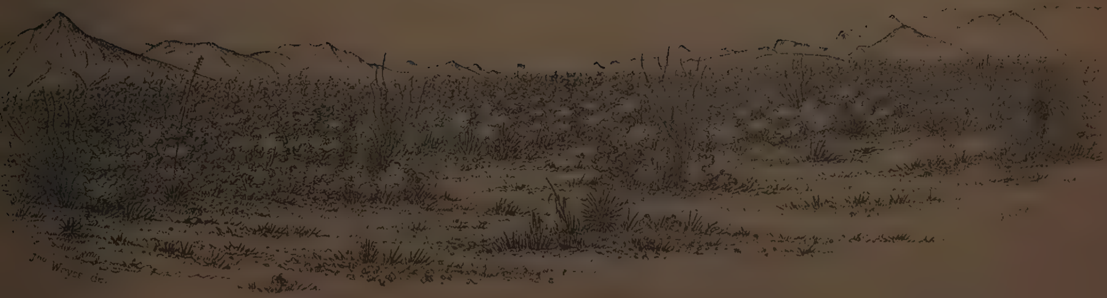


VIEW FROM EM[illegible] MONUMENT AT THE SAN BERNARDINO SPRINGS LOOKING EAST ALONG THE PARALLEL OF [illegible]

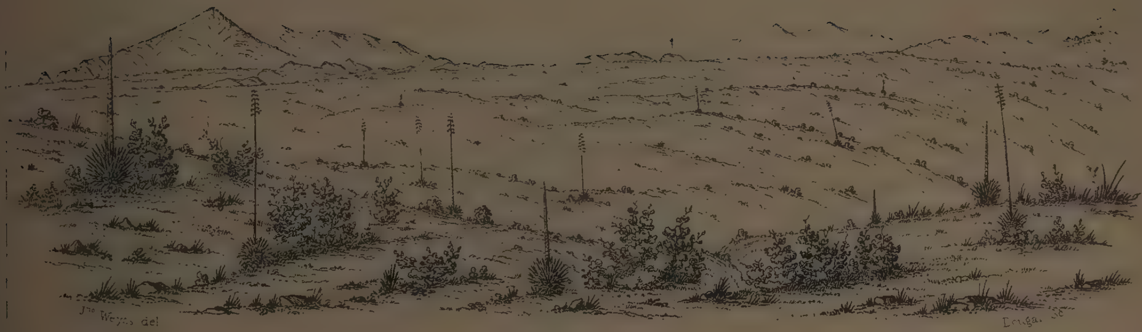
VIEW ALONG THE LINE [illegible] LOOKING WEST WHERE IT CROSSES THE FIRST RANGE OF HILLS WEST OF SAN BERNARDINO



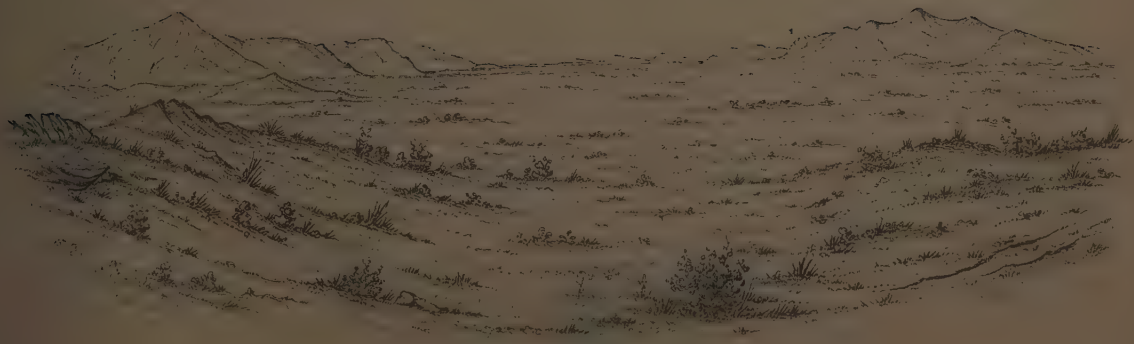
VIEW FROM THE MONUMENT NEAR SAN BERNARDINO LOOKING WEST ALONG THE PARALLEL [illegible]



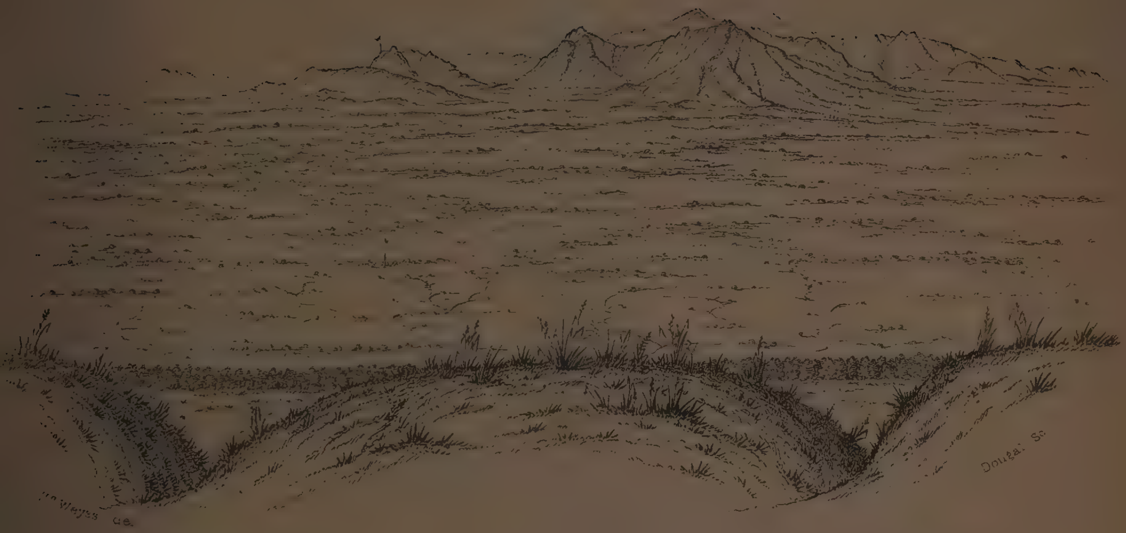
VIEW ON THE PRAIRIE BETWEEN SAN BERNARDINO AND THE SAN PEDRO, LOOKING WEST
ALONG THE PARALLEL 31° 20′ (Nº 1)



VIEW ON THE PRAIRIE BETWEEN SAN BERNARDINO AND THE SAN PEDRO. LOOKING WEST
ALONG THE PARALLEL 31° 20′ (Nº 2)

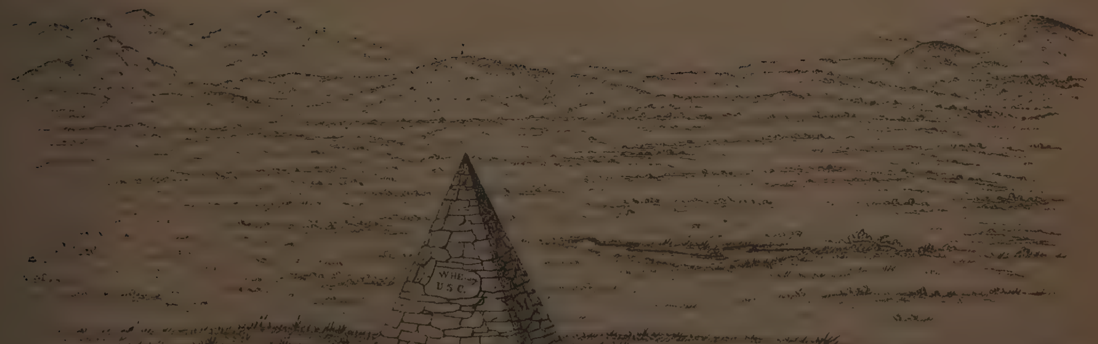


[illegible] RDINO AND THE SAN PEDRO. LOOKING WEST
[illegible] 31° 20′ (Nº 3)

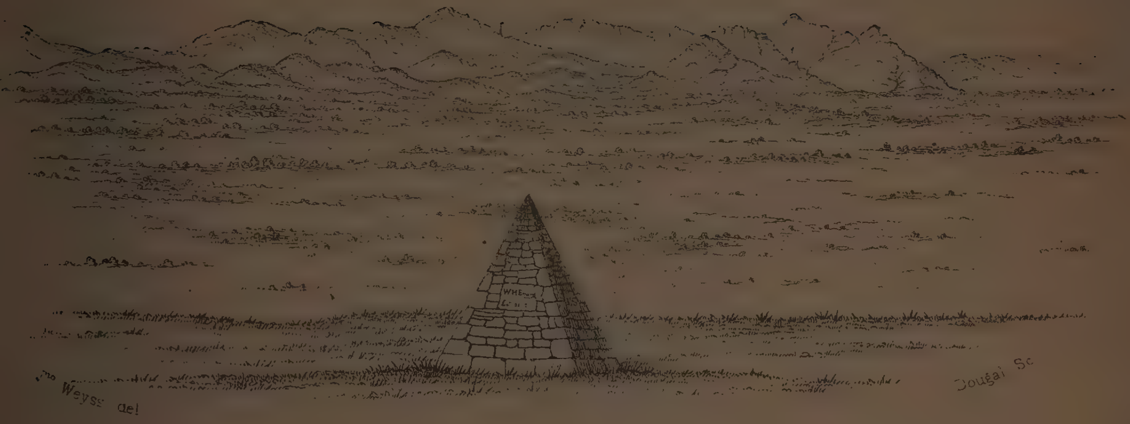


VIEW FROM THE MONUMENT ON THE RIO SAN PEDRO, LOOKING WEST ALONG THE PARALLEL [illegible]

30

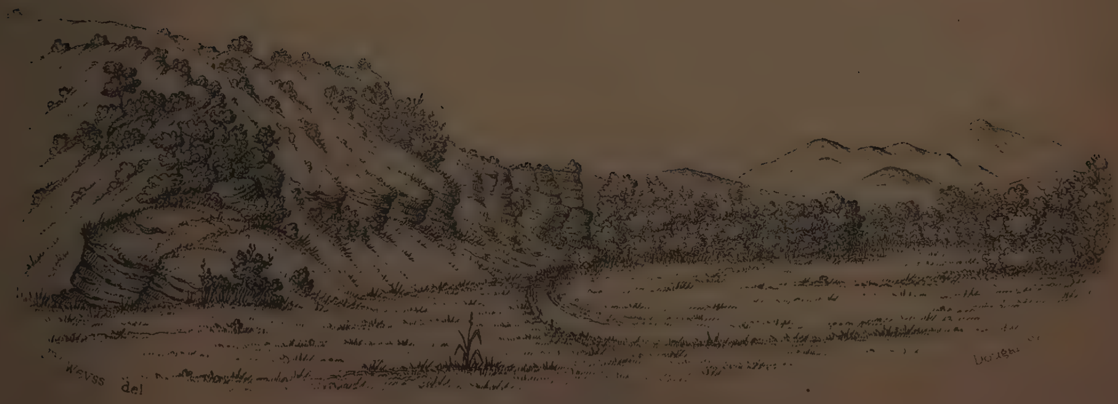


[illegible] OF SANTA [illegible]



VIEW FROM EMORYS MONUMENT NORTH OF SANTA CRUZ, LOOKING WEST ALONG THE PARALLEL 31° 20'

32



VIEW FROM THE MONUMENT NEAR LOS NOGALES LOOKING SOUTH

[illegible] along the line

CHAPTER VII.

FROM THE 111TH MERIDIAN OF LONGITUDE TO THE PACIFIC OCEAN.

REPORT OF LIEUT. MICHLER.

FORT YUMA.—COLORADO AND GILA.—SLOUGHS OR ARROYOS.—SITE OF AN OLD PRESIDIO.—BOUNDARY LINE.—SAND BELT.—DESERT.—PANORAMA OF MOUNTAIN RANGES.—MIRAGE.—BOTTOM LAND AND VEGETATION.—EARTHQUAKES AND MUD VOLCANOES.—CLIMATE.—DUST STORMS.—INDIANS.—INITIAL POINT ON THE COLORADO.—TINAJAS ALTAS.—TULE.—SALADO.—AGUA DULCE.—QUITOBAQUITA.—CABEZA PRIETA.—SONOYTA.—ROAD ALONG THE GILA.—MARICOPAS.—PIMOS.—TUCSON.—SAN JAVIER.—TUBAC.—TOMOCACORI.—SOPORI.—ARIBACA.—SIERRAS ALONG THE AZIMUTH LINE.—PAPAGOS.—"TIERRA CALIENTE" OF SONORA.—SANTA MONICA.—SANTA ISABEL.—HEIGHT AND ABRUPTNESS OF MOUNTAIN RIDGES.—EASTERN SLOPE.—COLORADO DESERT.—NEW RIVER.—DISTANCES.

OFFICE UNITED STATES AND MEXICAN BOUNDARY SURVEY,
Washington, July 29, 1856.

SIR: The following extract is taken from your orders to me, dated Washington, D. C., August 29, 1854: "You are charged with the important service of running that part of the boundary line between the United States and Mexico which commences on the Colorado river, twenty English miles below or south of the junction of that river and the Gila, until you meet the party running the line under my immediate direction, from El Paso westward."

Having complied with your instructions, I now have the honor to submit to you a report of the manner in which the work has been executed, and describe that portion of the country to which our duty particularly confined us, and the Indian tribes frequenting the immediate neighborhood of the line.

Sailing from New York on September 20, 1854, myself and assistants proceeded, via Aspinwall, Panama and San Francisco, to San Diego. All necessary instruments having been provided before leaving the eastern cities, preparations for the transportation, subsistence, and organization of a party occupied my attention in the last named places. These completed, we left San Diego on the 16th of November, for Fort Yuma, which place was reached, after journeying over mountains and deserts, on the 9th of December. This road, the most difficult I have ever travelled for heavily-loaded wagons, has been already spoken of in your military reconnoissances in New Mexico and California, and a further description would be unnecessary. Its distance, measured with a viameter, is 217 miles.

On the right bank of the Colorado, and in a bend opposite the mouth of the Gila, rises up a low irregular hill, from seventy to eighty feet in height; on the water-side there is a perpendicular cliff; the other sides are less steep, but equally rugged. This hill is of Plutonic origin, and presents a bleak, dreary appearance. The surface is covered with sharp, volcanic rocks, cutting like glass under the tread, and is destitute of every form of vegetation, except the euphorbia, a rank poison, and used by the Indians as an antidote against the bite of the rattlesnake. Such is the site of the military post of Fort Yuma. This hill, cleft by the Colorado at

its junction with the Gila, and extending a short distance, unites with a larger mass of the same formation. A mile further south is another isolated hill, about 250 feet high, called Sierra Prieta, with its base imbedded in the white sands of the desert. These hills were once one and the same; one river runnning around its north, and the other its south base, (their old beds being still traceable,) and both uniting on the west. By some freak in the laws of nature, an eruption in the bowels of the earth caused an upheaving of this whole section of country, and changed the beds of these rivers: the one now runs due south, and the other due north, before uniting. Their currents act on the same line and are diametrically opposed, and as the waters meet, neither willing to yield, they open a passage through the highest part of the hill, turning at right angles to their original courses and flowing towards the west. The cleft thus made is about 240 feet in width. The Colorado furnishes more than two-thirds of the water. At an average stage at the junction, the quantity discharged per second was found, from a mean of several experiments, to be 6,249 cubic feet, and the velocity three feet per second. At the same point the depth of the channel is about eighteen feet. It then widens, and becomes more shallow. By daily observations with the barometer, the level of the rivers at their confluence was found to be 275 feet above that of the sea at San Diego. The Colorado, as its name signifies, is of a reddish color, and carries down immense quantities of sand and mud. The water is sweet, and excellent for drinking, but does not bear keeping long, as it soon putrifies. The Gila is clearer, and its temperature warmer, but somewhat brackish in its taste, owing to the large quantity of earthy salts held in solution.

For twenty miles above the post the Colorado spreads out into a wide and low sheet of water; but above that point, to the entrance of the Great Cañon, it becomes more narrow and deep. An expedition under Major Heintzelman ascended this river in boats in September, 1852. Another is contemplated, when it is the purpose to carry a steamboat up as far as possible, provided the government will render some assistance by an appropriation sufficiently large to insure the safety of the boat. The belief is entertained and strongly advocated, that the Colorado will be the means of supplying the Mormon territory, instead of the great extent of land transportation now used for that purpose. Its head-waters approach the large settlements in Utah, and may one day become the means of bearing away the produce and stock of these pioneers of the far West. With this idea prominent in the minds of speculators, a city on paper, bearing the name of "Colorado City," has already been surveyed, the streets and blocks marked out, and many of them sold. It is situated on the left bank, opposite Fort Yuma.

From the description given me of the Great Cañon, it must resemble in appearance and character those along the Rio Bravo del Norte, upon which I have already reported.

The Colorado is said to have but few tributaries; the Gila has several, emptying in above and below the Pimos villages. The annual rise in both rivers usually takes place in the months of May and June, sometimes as late as July, and is caused by the melting of the snows in the mountains near their head-waters; the freshets are not of long duration. Frequently the one stream will be up and the other down. The Gila becomes so low that a sand-bar forms at its mouth during the summer, and at no time does it supply much water. The Colorado, on the contrary, is navigable for small steamers, drawing two and two and a half feet water, as high up as Fort Yuma. Sailing-vessels take stores from the Pacific through the Gulf of California, and up the river, sixty miles above its mouth, to Point Invincible, or near Hardy's Colorado, and there discharge their cargoes upon the river steamers; the latter then transport them ninety miles to the junction—the present contract price per ton being seventy-five dollars, and

the boat carrying from fifty to sixty tons. This is a great saving, as the cost of transportation of stores by trains across the desert is enormous. The navigation is pretty good, but, like all streams of the same nature, the channel frequently changes, owing to the shifting sands and the instability of its banks. The nature of the latter varies; thirty miles above the junction, the river is walled in by mountains throughout nearly its whole extent; and fifteen miles lower down, it passes for a short distance through the Santa Isabel range. From there to the salt marshes near the mouth, except at the junction with the Gila, the banks are alluvial, caving in and shifting with every rise and fall; they become very low and flat, and are overflowed for miles during spring tides; a heavy *bore* then rushes in, swell upon swell, and renders it very dangerous for small boats. The tides ascend for thirty-seven miles. The lowest depth of the channel is three feet, its mean or average stage of water six, and its highest about twenty feet. During very high freshets the water flows back for many miles through the arroyos or sloughs which intersect the country: large lagunas or lakes are thus formed, such as the "Big Laguna," and "New River" or "Providence creek," found on the road from San Diego, and also Hardy's false Colorado; these remain filled for a long time—some nearly the entire year. Whenever they occur a broad slough, north and west of the post, is filled, and completely isolates it from the main land, communication being had only by means of boats.

There are only three kinds of fish, that are at all palatable, caught in the Colorado—the hump-back, trout, and buffalo—all very soft and of a muddy flavor, full of small bones and of most inferior quality.

Fort Yuma is well located for defence against the Indians; the only point (Sierra Prieta) commanding it is beyond the reach of arrows. It affords a distant and fine view of the surrounding country. In the very interesting report of Major Heintzelman, made to the commanding general of the Pacific department, in July, 1853, he says: "The post is on the site of a Presidio established about seventy-seven years ago by the Spaniards. Padre Pedro Garces came out here with a San Gabriel Indian, and reported this a favorable position for a mission. The next year he and Padre Kino came out with troops and established a mission at the junction, and José Maria Ortegas, son of Don Francisco Ortegas, captain and commandante of the expedition of the discoverers of Alta California, founded the Presidio. The position is described between the sierras of San Pedro and San Pablo. A little east of north from here, forty-five miles, on the top of a ridge of barren mountains, is a detached rock, several hundred feet high, resembling a dome, which may have given it the name of St. Peter; and in a direction west of north, about eighteen miles distant, on another range of mountains, rises a solitary rock, five hundred feet high, which we have called Chimney Peak, and which must have borne the other name."

Our camp lay opposite the military post, on the left bank of the Colorado, between the Plutonic ridge on the east, and a low range of sand and gravel hills, called the Yuma hills, on the west; these latter end abruptly at the water's edge, no trace of them being seen on the opposite side, and extend south to the base of the Sierra Prieta. They were interesting from the beautiful specimens of quartz found upon them, among which were fortification and moss agates, chalcedony, jasper, and opals, and various fine pieces of petrifactions of mezquite, cottonwood, and indigenous plants, and one of palm-wood. Seven miles and a half by the river, below the post, is another high, prominent, and isolated hill, called Pilot Knob, similar in general appearance and formation to those spoken of. The boundary line from the initial point on the Pacific ocean runs tangent to the southern base of this butte, until it intersects the middle of the Colorado, a short distance below the south ferry. An iron monument formerly marked the

line near this place, on a high knoll, but has been broken into a thousand pieces by the Indians; its locality, however, is well defined. From this point of intersection the boundary follows down the middle of the stream to a point 20 English miles, in a straight line, below the junction of the Gila and Colorado.

Near Pilot Knob, a large belt of white, glistening sand encroaches upon the river to within a short distance of its right bank; it is fifteen miles long by five wide, and about forty feet high; from its gradual approachment, it threatens to dislodge the river and efface its present bed. Twelve miles above the junction, a spur of the "Sierra de la Gila," a mass of sharp, angular, igneous rocks, thrown together in the most incongruous shapes, sets into the Rio Gila; its bearing is northwest and southeast, and it extends as far as the eye can see. From the base of this mountain, along its whole length, extends out towards the Gila and Colorado a level plain of gravel and sand, in breadth from twenty to fifty miles, and stretching far south until it mingles with the hillocks of white sand which define the eastern shore, along the Gulf of California. It limits the bottom-lands, sometimes touching the river, as at Ogden's landing, and again recedes, leaving a fertile tract of several miles in width. The latter is from two to ten feet above the surface of the water, and the former rises in bluff banks from twenty to forty feet in height. The plain is a perfect desert, marked by an entire absence of water, and destitute of vegetation, save some few sickly plants: the Larrea Mexicana and the Fouquiera, the natural growth of such barren localities, only add to the gloomy sensation produced by the scorched sterility spread out to view, with jagged ridges of hills lying in the back-ground. The bottom-land on the right bank of the Colorado is bounded by a similar plain, which extends south to the base of the mountains of Lower California. This whole country is truly a desolate region; rich, however, in geological and mineralogical material.

Standing on the top of the Sierra Prieta, you have a magnificent panorama of the high peaks, rugged sides, and angular outlines of the mountain ranges which encircle you. From this point, looking westward and following the points of the compass round towards the north, your eye first rests upon Avie Quah-la-Altwa, (Avie signifying mountain, in the Indian tongue,) or Pilot Knob, as known to emigrants; a little further on, Avie A-re-ña Hampan, connecting with the low ranges of white sand-hills already spoken of; then Avie Qui-a-sa viño; to the northwest a light and a dark range, Avie Qui-a-sa and Avie Haz-e-nas; afterwards Avie Sut-ma-mou-ra—all isolated ridges. Ranging across the north is Avie Mil-li-ket, its highest peak called by the Americans "Chimney Peak," and by the old Jesuits "San Pablo." The Indian name is in honor of a learned and wise chief, who became a deity after his death. He occupies a large cavern in the mountains, the entrance to which is guarded by a raccoon, a pet during his stay upon earth; the path which leads from the cave to the river bank is said to be distinctly marked by his foot-prints. He seems to enjoy long intervals of sleep, and when aroused from his slumbers by the wickedness of his worshippers, he is believed to change his position, and the act of rolling over causes the rumbling earthquakes which are frequently felt throughout this section of country. During the last shock experienced there, it is reported that a large piece of the peak of Mil-li-ket, solid rock as it is, was broken off, and rolled into the plain beneath. The Indians, considering it a part of their religious duty, make regular visits to the spot, like Mahomedans to the shrine of Mahomet. To the east of Mil-li-ket is another remarkable-looking peak, called Pin-chie, the allegorical allusion scarcely bearing mention; the two are almost in juxtaposition. Avie Mil-li-ket is quite an extended range, and is about twenty-four or five miles north of Fort Yuma. To the northeast, and about forty-five miles distant, is Avie Tok-a-va or Dome mountain, or

Sierra de San Pedro, a solid rock many feet in height, and resembling the dome of a cathedral. Some god is supposed to inhabit this range. Near it is a second peak, called the "broken dome." To the east, and extending south, are Cone mountain, of the Santa Isabel range, and the Sierra de la Gila; Antelope peak is the principal one of the latter. To the southeast, mountain after mountain rises up; to the south, those of Lower California are plainly visible, so high that snow envelopes their tops; and when the southwest winds blow, they are more chilly than those from the north, bearing along with them the cold air of the snow-clad peaks. From a distance these mountain ranges look rugged in the extreme, although here and there, as you watch the play of the sun, you see reflected back perpendicular walls of smooth, white rock.

The atmosphere is so clear that you are able to see at long distances. In the morning a beautiful sight is afforded by the mirage. It has the effect, apparently, of raising the mountains and bringing them more plainly to view, and many are the fantastic and peculiar shapes that are represented.

We turn from this barren view and look with pleasure upon the bright green foliage which marks the course of the Colorado. The river-bottom, varying in width, is generally broad and fertile—an alluvial deposite, covered with a thick growth of timber. Large cotton-wood trees, different varieties of willow thickly matted together, and impenetrable thickets of arrow and grease-wood, grow near the river; further back the mezquite of two kinds—the flat-pod and the screw-bean—thrive and flourish. The bottom is intersected by innumerable lagoons and sloughs, which during the annual rises fill to overflowing, and irrigate the soil. The earth is consequently impregnated with the salts of potash, magnesia, and soda, which are held in solution by the water. No vegetation will grow beyond the influence of these overflows, and when a white efflorescence appears upon the surface of the ground it is useless to plant, as nothing edible for man or beast will grow there.

The delta of the Colorado and Gila is below high-water mark, and is subjected to overflows. The soil is a mixture of clay and sand. There are some few varieties of grass very scatteringly distributed. The distance from Fort Yuma to the mouth of the Colorado is about one hundred and sixty miles. The whole of the country strongly resembles the Rio Bravo del Norte in the general appearance of its vegetable forms; varieties of cacti, the maguey plant, Larrea Mexicana, and the fouquiera, are all found here. Although both regions are probably of the same geological structure, they are not equal in richness, that upon the Rio Grande being the most fertile. To add to the interest of this section of our land, we find it is subject to earthquakes, by which it is sometimes depressed and sometimes elevated. To quote from a very interesting account given by Major Heintzelman of a visit made to the scene in November, 1852, he says: "The low ground was full of cracks, from many of which there gushed forth sulphurous water, mud, and sand. At the time, great changes were made in the river-bed. The earthquake appears to have been occasioned by an accumulation of gases and steam in the caverns of the earth. The elasticity of these forced an escape through a pond forty-five miles below, on the desert between the river and coast mountains, the repeated escapes causing rumbling and shocks. It is an old orifice, that has been closed several years, so that the first effort occasioned the most violent explosion. The steam rose in a beautiful snowy jet more than a hundred feet in the air, and spread, appearing above the tops of the mountains like a white cloud, and gradually disappeared. This was repeated several times, but on a much smaller scale."

When the Major visited the place three months later, "these jets took place at irregular intervals of fifteen or twenty minutes, and had a beautiful effect as they rose, mingled with the black

water and mud of the ponds. The temperature in the principal pond was 118°, and in a smaller one 135°. One of the mud-holes from which gas escaped was 170°. The air was filled with sulphuretted hydrogen, and in the crevices were beautiful yellow crystals of sulphur. The ground was covered with a white efflorescence, tinged with red and yellow."

The climate of this region is in accordance with everything else relating to it. Encamped there during the three winter months, we found the weather generally mild, although the changes in temperature were very great; the thermometer during part of this time as high as 90° Fahrenheit, and then as low as 30°. The days were sometimes uncomfortably warm, and the nights intensely cold. Living and sleeping in tents all the time, we seldom had occasion to have a camp-fire except at early dawn. Owing to the clearness of the skies, the radiation is extremely rapid, and ice forms quickly.

Having returned the following August to Fort Yuma, the thermometer in the shade at the post was found to be 116° Fahrenheit, and over 120° in the shade along the river. The heat, commencing to be excessive in May, becomes almost unendurable in the months of June, July, and August. Even in winter the sun is so hot, and the direct as well as reflected light upon the sand-plains so dazzling, that, excepting a couple of hours after daybreak and an hour before sunset, it is only possible to see objects through the best instrumental telescopes in the most distorted shapes—a thin white pole appearing as a tall column of the whitest fleece.

In this belt of country rain seldom falls; in the distance dark clouds may be seen hanging over the California and Sonoranian mountains, but they seldom visit the intermediate localities. During the whole of one year they had but two inches of rain. After our arrival a few drops from some passing cloud fell in the two winter months, December and January, and in the following February .07 of an inch. The coast rains take place during the winter; and the rainy season in Sonora, the Mexican state south of the boundary line, in the months of July, August, and September. Spring, in the intermediate section, puts forth its thick green foliage in February, without any rains to refresh and cool the parched ground.

Instead of storms of rain during the winter and spring, they have those of dust and sand. These are caused by high and strong winds sweeping over the desert plains, coming principally from the northwest, raising and carrying before them, like mist, clouds of pulverized sand and dust. You can watch them in their progress as they approach for hours beforehand, and when they reach you the dust penetrates into every crevice, the finest silk not being impervious to it. They last generally a day; sometimes three. The winds blow up quickly and violently, and it is useless to attempt to work with nice instruments. These dust-storms were our great drawbacks, as it was impossible to see many feet distant, and then only at the risk of being blinded. The gusts of wind which produce this unpleasant effect in winter are in summer like the simoons of the Sahara—they sweep over and scorch the land, burning like the hot blasts of a furnace.

Think of those officers and soldiers who are so unfortunate as to be stationed at Fort Yuma. Two companies of artillery now garrison the post; their quarters have heretofore been Mexican *jacals*—upright mezquite poles, plastered with mud and covered with a thatching of arrow-wood; like so much powder, a single spark ignites them, and they burn like a flash in the pan. Dust and rain, as well as the eyes of the curious, penetrate through the crevices, the sun only being denied admission. When I left they were engaged in building new quarters of adobes, (sun-dried brick.) As every other comfort is denied them, their dwellings at least should be substantial and cool.

Arthur Schott del.

Lith. of Sarony & C.° New York

DIEGEÑOS.

Among the curiosities of the country are its aborigines. On the road from San Diego to Fort Yuma we passed through several Indian settlements of the Diegeño tribe, at San Pasqual, Santa Isabella, San Felipe, &c. These Indians were converted by the Jesuits, who many years ago organized missions throughout this country; they became partly civilized, and were industrious and happy, and collected many comforts about them. Naturally lazy, and incapable of self-government, and deeply imbued with all the traits of the wild Indian, they easily degenerated after the missions had fallen from under the rule of the church, and have become absolutely worse than in their original condition. Then they were simply children of nature, following the bent of their inclinations, with few comforts, and fewer wants; now they have learned sufficient to be exceedingly avaricious and unscrupulous—a herd of drones and beggars, their dispositions thievish, and forever on the watch to commit some petty larceny. They call themselves "Christianos." The degradation of the Indian woman is only surpassed by that of those off-scourings of creation, the male white population who wander over the country.

The women are beautifully developed, and superbly formed, their bodies as straight as an arrow; their features, however, are coarse and uninviting, their persons filthy, and their actions still more disgusting. They imitate the whites in dress, and in a single Indian group you see the odds and ends of clothing from all parts of the globe most fancifully and grotesquely worn. Don Tomas, the chief of the Santa Isabella Pueblos, is quite a fine-looking person, and has considerable reputation as a man and warrior. He goes about dressed in a full-dress soldier's coat and shirt, but no breeches; carries an old sabre as a sword of justice and rod of correction, judging from the way I saw him use the flat of it on the back of a drunken Indian.

The opposite picture is a lithograph of a Diegeño, wife and child—the one leading and the other riding a mule—as we met them travelling to the "Agua Caliente," near Warner's rancho.

There are many Indian tribes scattered throughout this part of California; but I will confine my remarks particularly to those dwelling on the Colorado and Gila. From about sixty miles above Fort Yuma to within a few miles of the most southern point of that part of the Colorado forming the boundary, live the Cuchanos, or Yumas. A belt of land of some few miles in width, forms neutral ground between them and the Cocopas; the latter living below, and near the mouth of the Colorado, within the limits of Mexico, and the former almost entirely in the United States. These, together with the Maricopas, who now live up the Gila among the Pimos, originally formed one tribe. Disagreeing upon the choice of chiefs, they separated; until recently, they have been deadly enemies, carrying on a war of extermination to the knife. The continued warfare with each other has compelled them to manifest a seeming friendship for the whites, has occasioned great loss of life and property, and been detrimental to their increase. In consequence of their great suffering, the Cuchanos have found it necessary and expedient to live near the post; every day, numbers are seen loitering about the parade-ground, and through the quarters of officers and men. These tribes speak the same dialect, follow the same habits and customs, and dress in the same manner and of the same materials. The Maricopas, however, are fast becoming embodied with the Pimos, and seldom visit their kinsmen. The Yumas and Cocopas are said to be very treacherous races; they conquer not by fair and honorable contest, but by craft and cunning, and midnight attack; they steal upon their enemies under the cover of night, and beat out the brains of their unsuspecting foes with clubs; or, under the garb of friendship and peace, invite each other to feasts, and suddenly

fall upon and kill their guests; or, taking advantage of the absence of the warriors from their villages, massacre the remaining men, old women, and small children, and carry off as prisoners the more youthful women and larger children. They look upon this kind of warfare as right and honorable. They follow their war expeditions on foot, possessing only a few horses.

Their hunting as well as war weapons are bows and arrows, clubs and knives. I have not seen a rifle or gun of any kind among them. The bow is made of willow; the arrows are of reed, part of the shaft of arrow-wood—the point tipped with a head of hard stone, either jasper or agate, small, but neatly and sharply edged; they are winged with the gay feathers of the various birds of this country. Their clubs are of mezquite wood, three or four feet long. On one occasion, as Major Fitzgerald was escorting a train up the river, he discovered them moving their families; pressing them too hard, they turned upon his command, and, in defiance of powder and ball, attacked it with clubs at the very bayonet's point and forced the soldiers to retire.

An instance of the stratagem and bad faith practised by these different tribes upon each other, was told me by the officers at the post. The Cocopas planned the massacre of all the captains of the Cuchanos in 1851, to accomplish which they intended inviting them to a feast and slaying them. The plan was overheard and told the Cuchanos; the latter fell upon the former the same night, killing several men, and carrying off women and children. To repay them, the Cocopas made a visit to the Cuchanos to recover their prisoners, and again invited the latter to a feast, who unsuspectingly accepted; during their absence, the Cocopas fell upon their villages and reciprocated the treatment they had previously received. Macedon, the principal chief of the Cuchanos, was killed on this occasion; he was much beloved by his tribe, and is spoken of as an intelligent and high-minded Indian; his death is said to have occasioned much grief. This was the time of the outbreak of Antonio Garras, who had leagued all the tribes of Indians of South California against the whites, intending by a simultaneous and well-concerted attack, to annihilate the Americans and drive them from the country. He was afterwards taken and shot by the military at San Diego, where his grave is pointed out to the passer-by.

On several occasions, the officers commanding at Fort Yuma have been instrumental in securing peace; but the Indians being naturally suspicious of each other, it does not continue long. A treaty was made between them whilst we were encamped on the Colorado. The Cuchanos were anxious for, and had often sent down their women to propose one. Owing to the number of intermarriages among the tribes, this is the usual mode of proceeding. At last, through the influence of Major Thomas, a day was appointed for both parties to meet at the post. Francisco, an intelligent, splendid-looking young Indian, and brother to the murdered Macedon, was sent down the river to bring up the Cocopas chiefs. Four of them and their women arrived on board the steamboat. José, Jepita, Coyote, and Colorado, representing the Cocopas, and Pasqual, an immense man, near six feet four inches in height, Caballo-en-pelo, and Vincente, figured on the part of the Cuchanos. All made speeches; and when assenting to any particular view advanced, on either side, they commenced with the principal chief, and passing round the whole circle from one to another, in the order of rank, each one expressed his approval by the monosyllable, "good." After the words of the treaty had been agreed upon, the Major asked each one to make a sign or mark opposite his name. Before having time to explain its purport Jepita jumped up, and, with very energetic language and appropriate

gesture, stated that their word was as good as their mark; but that they would make any of their signs, such as "kneeling upon one knee," "raising the hand to heaven," or "embracing." Immediately putting his words into effect, he walked up to Pasqual, and taking his large frame in his arms, gave him a long and tight embrace. After the ceremony was over, rations were issued to them, which they devoured with right good will. They then went about begging for old clothes, and in the evening celebrated one of their games.

The association of the Indian with the white tends to cause a rapid decrease by the introduction of diseases among them heretofore unknown; war, too, among themselves is a great exterminator, but has the advantage of making them more dependent upon the whites. Thinking the military will protect all, they draw near to the posts, and from presents learn the use of various articles of clothing and food; these, now regarded as luxuries, will, in time, become to them necessities. They, too, learn and see the advantages which the whites possess over them in every respect, and are not slow either to admit or account for it. They say that whites and Indians at one time were all one tribe, equally well informed, and acquainted with the use of implements of husbandry and of all useful articles. Differing upon the choice of a chief, they quarrelled, and during the night the whites stole a march upon them, carrying away everything, and leaving the poor Indian in the dark. These Indians are of a dark brown color; during the cold weather, of dull and dirty appearance, but in summer bright and glossy from bathing in the river. They are most expert swimmers. They are of the medium height, well formed, and slender; not muscular, the deltoid muscles alone being largely developed, arising from the peculiar mode of throwing the arms while swimming; active and clean-limbed; their features not disagreeable, although they have large noses, thick lips, and high cheek-bones; their chests are well developed and figures manly, indicating activity but not strength. The women are under the medium height: their figures are fine and plump; the bust is well developed, the mamma firm; the arms finely moulded; the hands small and pretty; the legs beautifully formed and well rounded, and nicely-turned ankles; the feet are natually small, but become much enlarged by not being protected. Altogether they present a very voluptuous appearance. Their deportment is modest, and their carriage and bearing erect and graceful. They all travel on foot, and when going long distances, at a slow trot.

An essential article of dress worn by the men is a piece of coarse cotton cloth, three or four feet long, passed between the legs, the ends drawn over a cord tied around the waist, and then allowed to fall loosely down. The women wear a very becoming and a very pretty dress. They take the inner bark of willow, cut into strips about an inch wide and sufficiently long to extend from the waist to the knee. A number of these pieces are woven together at one end and selvedged, the edge long enough to go half-way round the body; two of these pieces—the one called the a-be-hike, and the other the al-ter-dick—are secured in front and behind by means of a girdle of strips composed of the same material, and covering the body from the hips to the knees. The front portion is woven plain, but the back into an angular shape, with a lump at each side, answering the same purpose and appearing like a bustle. On this protuberance the women carry their children of two or three years of age, a rope passing around the groins of the child and the ends tied together in front of the mother; as she approaches you, nothing is seen but a little foot dangling down on each side. The belles of the tribe, however, when they can obtain the material, make the front of white woolen cord; they take a white blanket, pick the wool loose, and twist it into cords of some thickness, and use this in place of

the willow-bark; they tip the ends of the cords with bits of red flannel; the girdle is then made of cords of the same kind, only variegated with different colors, red, white, and blue. When they lie down to sleep, they strip and cover themselves with their clothes, having nothing beneath them; in winter they keep warm by lying near a fire. The hair of both males and females is cut square across the forehead above the eyes, the sides and back left long; the men wear it very long, as it is considered a great ornament, and braid it in rolls; the latter are used for the purpose of securing their bows, arrows, and clothes above water when swimming a river. The women do not wear it as long as the men. They speak of one of their celebrities, now dead, with great respect, as the warrior with the very long hair. Both sexes paint; the usual colors are vermilion, black, and blue. A very few are tattooed; this operation is performed by pricking the skin with the sharp point of a flint, and sprinkling in the wound the dust of charcoal. Very few ornaments are used. The chiefs of the various bands seem to have a distinct official badge, consisting of pearl-shells suspended by rings from the nose. Both men and women are passionately fond of glass beads.

Although their language is not sweet, the sounds being guttural and harsh, still their names are very pretty. Three of the belles of the tribe were named Ma-vah, He-pa, and Le-och. There appears to be no marriage ceremony. If a man and woman like each other, they live together; if they afterwards disagree they can separate, provided there be no children, and even then they can marry again should both parties consent. Unmarried women are taken care of by the tribes; children can go from one hut or family to another, and will be fed and cared for as belonging to the tribe. Nor do they have any funeral ceremonies. When a death occurs they move their villages, although sometimes only a short distance, but never occupying exactly the same locality. The dead is burned; the body, dressed and surrounded with all the personal effects, is placed upon a funeral pile and consumed. No disposition is ever made of the ashes. A feast is celebrated, and if the deceased is possessed of any horses they are killed and eaten; his possessions are said to be bad, and are burnt or destroyed. The female relations of the departed mourn for many days, manifesting their grief by tearing out their hair, cutting their bodies, and destroying everything they possess, not even saving a vestige of their garments. If any member of the tribe should kill another, whether in the heat of battle or in cold blood, he returns to his home and atones for the necessity of having been compelled to commit the deed by keeping a fast for one moon; on such occasions he eats no meat—only vegetables—drinks only water, knows no woman, and bathes frequently during the day to purify the flesh.

Among these tribes they have a ceremony for celebrating the arrival of a virgin to the age of puberty. When the old women ascertain the fact, the whole tribe collect together and celebrate the occasion with a feast. The applicant for womanhood is placed in an oven or closely covered hut; this is made by digging a hole, in which they lay heated stones, covering them with twigs and bushes, upon which the novice is placed; hot water is then thrown upon the stones, and when completely steamed and saturated with profuse perspiration, she plunges into the river and takes a bath. This process is kept up for three days, maintaining a fast all the time. The feast celebrated, the girl is considered a woman, and is ready for marriage; maidens, however, do not generally marry early. They become fully developed at about twelve or fourteen, and grow so rapidly that in a few years they look coarse and fat. Previous to a birth, the mother leaves her village for some short distance and lives by herself until a month after the child is born; the band to which she belongs then assembles and selects a name for

Arthur Schott del.

YUMAS.
FIGURE TO THE LEFT, PORTRAIT OF LEOCH.

Arthur Schott del.

Lith. of SARONY, MAJOR & KNAPP, New York.

CO-CO-PAS.

the little one, which is given with some trivial ceremony, and the mother then returns with it to her home.

Nothing is known of their religion. At one time they profess to worship the sun and moon; at another they say the Indian and white man have the same God; then you find them making pilgrimages to the sepulchre of some departed chieftain, celebrated for deeds of valor or civic honors.

As to their government, they are divided into bands, each having its own head. There is one principal hereditary chief presiding over the whole. Each of the former, with the advice of its members, decides upon all affairs relating directly to the band to which he belongs. Any important business affecting the whole, is acted upon by a council of chiefs—the principal chieftain governing their deliberations. Each chief punishes delinquents by beating them across the back with a stick. Criminals brought before the general council for examination, if convicted, are placed in the hands of a regularly appointed executioner of the tribe, who inflicts such punishment as the council may direct.

An execution took place among the Cuchanos whilst we were in their neighborhood, which created great sorrow among us all. An Indian boy named "Bill" was in the habit of going up and down the river on board the steamboat, and frequently visited the post and our camp. Being very smart and good-natured, he became a great favorite; and speaking some little English and Spanish, could act as interpreter. He was secretly accused and tried before the council for "being under the influence of evil spirits"—the evidence going to show, that for the sake of frightening a little child he had forewarned it of its death on the following day, which, in reality, accidentally took place. He was convicted and sentenced to be executed. Whilst seated on the ground with three others of his tribe, laughing, talking, and playing cards, the executioner walked up behind him and struck him three blows upon the forehead and each temple, killing him instantly.

Their games are few. The principal one is called mo-upp, or in Spanish, redondo, played with two poles fifteen feet long, and a ring some few inches in diameter. They play another with sticks, like jack-straws; also monte and other games of cards, but know no ball plays. Old and young join in the games. Different from most Indians, they seem to be good-natured, laughing and talking all the time. They are very affectionate towards each other, and it is not unusual to see them walking with their arms around each other's waists.

Music is not much cultivated among them. They sing some few monotonous songs, and the beaux captivate the hearts of their lady-loves by playing on a flute made of cane. They manufacture but few articles. The women make baskets of willow, and also of tule, which are impervious to water; also earthen ollas or pots, which are used for cooking and for cooling water; they answer the latter purpose very well—being porous, the water oozes out and evaporates on the surface. The men make headstalls and reatas for horses.

Although constantly in the water, these Indians never use canoes, but swim from shore to shore; and in the event of moving their families some distance down stream, they place them on rafts of wood or balsas of rushes, push them out in the channel, and trust to the current, directing their movements with a pole.

Owing to the mild climate and the absence of rains, they require but little shelter, and their houses are of the meanest construction. Sometimes they make them of upright poles a few feet in height, crossed horizontally by others on the top, upon which rest brush and dirt. The

side to the prevailing wind is sloped towards the ground. They usually select a sandy spot, as it is warmer in winter and cooler in summer.

Major Heintzelman, in speaking of their agriculture, says "it is simple; with an old axe, (if they are so fortunate as to possess one,) knives, and fire, a spot likely to overflow is cleared; after the waters subside, (those of the annual rise,) small holes are dug at proper intervals, a few inches deep, with a sharpened stick, having first removed the surface for an inch or two, as it is apt to cake; the ground is tasted; if salt, rejected, and if not, the seeds are planted. No further care is required but to remove the weeds, which grow most luxuriantly wherever the water has been. They cultivate watermelons, muskmelons, pumpkins, corn, and beans. The watermelons are small and indifferent, muskmelons large, and pumpkins good; these latter they cut and dry for winter use. Wheat is planted in the same manner, near the lagoons, in December or January, and ripens in May or June. It has a fine plump grain and well-filled heads. They also grow grass-seed for food; it is prepared by pounding the seed in wooden mortars made of mezquite, or in the ground. With water the meal is kneaded into a mass, and then dried in the sun. The mezquite bean is prepared in the same manner, and will keep to the next season. The pod-mezquite begins to ripen the latter part of June; the screw-bean a little later. Both contain a great deal of saccharine matter; the latter is so full, it furnishes, by boiling, a palatable molasses; and from the former, by boiling and fermentation, a tolerably good drink may be made. The great dependence of the Indian for food, besides the product of his fields, is the mezquite-bean. Mules form a favorite article of food; but horses are so highly prized, they seldom kill them, unless pressed by hunger or required by their customs." A lithographic sketch accompanies this report, depicting the appearance and dress of the Yumas, or Cuchanos.

Apart from my own observations of the Indians of the Colorado, I am very much indebted for my acquaintance with their habits and customs to the very interesting report of Major Heintzelman, from which I have taken the liberty to make some extracts, and also to frequent conversations with Major George H. Thomas, Dr. Robert J. Abbott, and other officers of the army stationed at Fort Yuma during our sojourn in its neighborhood. It may be pardonable in me to render here, by a passing word, an acknowledgment of the great kindness and consideration shown myself and assistants by all those officers whom we had the good fortune to meet after reaching the shores of the Pacific. Our wants were always kindly supplied, and all they could do was done, to expedite the work.

On examination, after arriving at Fort Yuma, it was found that the instruments were disarranged, and in some instances broken, in consequence of the numerous changes in the mode of transportation, and the rough road travelled over; they were, however, soon repaired, as well as circumstances would permit, and the work commenced very shortly after reaching the field of our operations.

Surveys of the meanderings of the rivers Gila and Colorado for short distances above their junction, and of the latter river from the junction down to the head of ship navigation, together with the roads in the neighborhood, were made by assistant surveyor A. C. V. Schott, assisted by Messrs. E. A. Phillips, C. Michler, and T. Cozzens. Owing to the thick underbrush along the banks, the work proved tedious.

Astronomical and meteorological observations were daily made by myself, assisted by Mr. G. Power, and the computations made by Mr. J. O'Donoghue. At the same time I carried on the triangulation "to a point on the Colorado river twenty English miles below its junction with the

Gila." In consequence of the thick growth of timber along the river, this was effected on the sand plain until near the terminal point. The timber on the bottom-land there is nearly two miles in width, and lines of sight for the theodolite had to be cut through it to approach the river. This obstruction delayed the work some time, and numerous dust-storms also impeded its progress, preventing the possibility of using any instrument for several days at a time.

On the 14th February, 1855, we moved the main camp from opposite Fort Yuma, in order to be more in the vicinity of our work; a beautiful mezquite grove near a laguna of fresh water was selected. This spot was close to the edge of the sand plain, and the nearest desirable one to the terminal point of the triangulation, about two miles distant in a direct line. It is the site of Fitzgerald's battle-ground, twenty-two miles, by the road, below Fort Yuma. We were here joined by our escort, company I, 1st artillery, officered by First Lieutenant (now captain) Francis E. Patterson, and Second Lieutenant Henry W. Closson.

By the 4th of March the triangulation and survey were all completed, an observatory erected near the initial point of the new azimuth line, (running eastward to the intersection of the 111th meridian west of Greenwich, with the parallel 31° 20′ north latitude,) and astronomical observations with the transit and zenith instrument commenced. Our lucky stars did not, however, prove to be in the ascendency; first, clouds obscured them, and then the rising waters of the Colorado did not leave us long undisturbed. There came a freshet from the Gila, far up in the mountains, causing the Colorado to rise very slowly—so slowly that we anticipated no danger. The sloughs began to fill up between the observatory and the camp; the men bridged them, and still we hoped to see the water recede before forcing us to move. Day after day it continued to advance upon us until the night of the 19th, when the instruments were packed and moved to a higher point, five hundred yards distant. By this time the water had entered the observatory, and to reach it we were compelled to wade waist-deep for nearly the whole of that distance. An extract from my notes of the 20th says: "Compelled again to move the instruments and carry them up to camp; every slough is filled, all rapidly rising, and several swimming deep; rafts built to transport the men over them; all the men in water up to their breasts, and instruments only kept dry by being carried on their heads. About noon all safely in camp; water within fifty feet of it, and everybody getting ready to leave. At sunset the river still continues rising, and gradually approaches camp, but so slowly that we are still in doubt. At 2 o'clock a. m., decided to take to the sand-hills; the long roll was beaten, the camp struck, the train loaded, and all moved on the high plain. Behind us lay a desert of sand forty miles across, and in front was spread a sheet of water several miles in breadth. From fifteen hundred feet the Colorado had widened to at least five miles."

After being forced from our position, the river commenced falling back into its old channel. The bottom-land had become so boggy, it was many days before we were able to reach our observatory. In the mean time, that portion of the Mexican commission appointed to co-operate with me arrived. The party was composed of Don Francisco Jimenez, 1st engineer, in charge, assisted by Señores Manual Alemán and Augustine Diaz, 2d engineers. Captain Hilarion Garcia and Lieutenant Romero were the officers of the escort.

Having already made much progress in the work, Mr. Jimenez consented to adopt the initial point fixed by me. He also accepted its longitude as determined by my triangulation. Having succeeded at length in reaching the river, we were both enabled to commence observing for latitude on the night of the 1st of April. After ten nights of successive observations a mean of the results of each party was taken as the final determination. The latitude of this initial

point on the Colorado is 32° 29′ 44″.45 north, and the longitude of same 114° 48′ 44″.53 west of Greenwich. The computed azimuth of the line connecting this point with the intersection of the 111th meridian and parallel 31° 20′ north, forming part of the boundary between the United States and Mexico, is at the initial point 71° 20′ 43″.8 southeast, and at the intersection 69° 19′ 45″.94 northwest, and its length 237.63565 English miles. The mean of eighty barometrical observations at this point is 29.871 inches, — .020 for non-periodic error = 29.851; the non-periodic error was obtained by comparison with observations made at San Diego. The height of this point above the level of the sea at San Diego is 156.3 feet; its distance below the junction by the meanderings of the river is 27.9 miles, making the mean fall of the river between these two points 4.26 feet per mile.

The magnetic variation of the initial point in March, 1855, was 12° 37′ 30″ east of north.

As it was impossible to mark the exact initial point in the middle of the stream, Mr. Jimenez and myself established the first monument 3,164.84 feet distant from it, in the direction of the line, at its intersection with the meridian of the observatory. The azimuth of this monument is 71° 20′ 25″ southwest. Monument II, of cast iron, and pyramidal in form, is placed on the edge of the sand plain, as this position is more permanent and free from the action of freshets in the Colorado. I give its astronomical position: Latitude 32° 29′ 01″.48 north, and longitude 114° 46′ 14″.43 west of Greenwich. The azimuth of the line is 71° 19′ 23″.18 southeast; its distance from the initial point is 4,522.9 yards. This monument erected, everything was in readiness to prolong the line. An agreement was drawn up between both parties to facilitate the tracing and marking of the line by working conjointly.

From the junction to Sonoyta, a Mexican and Indian rancheria, or village, situated near the middle of the line, two roads run. The first one, which we will now describe, crosses the desert west of the Sierra de la Gila, in a southeast direction, to a pass through one of its ridges leading to water-holes, called by the Mexicans, "Tinajas Altas." These are natural wells formed in the gullies, or arroyos, on the sides of the mountains, by dams composed of fragments of rocks and sand washed down by heavy rains; they are filled up during the rainy seasons, and frequently furnish travellers with water for many months of the year, being, in fact, their only dependence. There are eight of these tinajas, one above the other, the highest two extremely difficult to reach; as the water is used from the lower ones you ascend to the next higher, passing it down by means of buckets. It is dangerous to attempt the highest, as it requires a skilful climber to ascend the mountain, which is of granitic origin, the rocks smooth and slippery. Although no vegetation marks the place, still it is readily found. A variety of birds frequent the spot, principally the small, delicate humming-bird. The "palo de fierro" and the "palo verde" grow near the base of the mountain.

The distance to the "Tinajas" is forty-five miles, over the desert plain already described; the first twelve through the heaviest kind of white sand, and it is next to an impossibility for a train to pass over it, even by doubling teams—twelve mules to each wagon. Sixteen miles and a half further on you reach the "Tinajas del Tule," situated in the mountains of the same name, called so from the few scattered blades of coarse grass growing in their vicinity. The water here is found in an arroyo, walled in by huge high masses of granitic rocks, which present a peculiar appearance, as they lie in smooth whitish lumps huddled together in every possible way. The road winds through the ridges of this sierra for many miles, and then passes over a plain in an easterly course until it turns the southern base of the "Cerro Salado." From this point it follows up the valley of a subterraneous creek, (at two points of which sweet, or slightly

brackish, water can be had by digging) to an Indian village called Quitobaquita, fifty-four miles from "Tule." Midway between these two places is a low mezquite flat called "Las Playas," containing charcos, or holes, which are filled during the rainy season with water.

The second road from the junction, known by the name of the "Cabeza Prieta" route, from passing near "Tinajas," in the mountain of that name, after continuing up the Gila for forty miles, leaves it and joins the first at "Las Playas." At Quitobaquita there are fine springs running for the greater part of the year.

The road continues along the course of the subterraneous stream until you reach the Rancho de Sonoyta, thirteen miles and a half further on. From the junction to within a short distance of this place, a heavy road of one hundred and thirty miles, you look on a desert country. Near Sonoyta it is well covered with mezquite timber; in the valley, to the east of the town, there is some salt grass; but to the west, as far as the Colorado, scarce a blade is to be seen. A dull, wide waste lies before you, interspersed with low sierras and mounds, covered with black igneous rocks. The soil is a mixture of sand and gravel; the reflection from its white surface adds still greater torment to the intense and scorching heat of the sun. Well do I recollect the ride from Sonoyta to Fort Yuma and back, in the middle of August, 1855. It was the most dreary and tiresome I have ever experienced. Imagination cannot picture a more dreary, sterile country, and we named it the "Mal Pais." The burnt lime-like appearance of the soil is ever before you; the very stones look like the scoriæ of a furnace; there is no grass, and but a sickly vegetation, more unpleasant to the sight than the barren earth itself; scarce an animal to be seen—not even the wolf or the hare to attract the attention, and, save the lizard and the horned frog, naught to give life and animation to this region. The eye may watch in vain for the flight of a bird; to add to all is the knowledge that there is not one drop of water to be depended upon from Sonoyta to the Colorado or Gila. All traces of the road are sometimes erased by the high winds sweeping the unstable soil before them, but death has strewn a continuous line of bleached bones and withered carcases of horses and cattle, as monuments to mark the way.

Although I travelled over it with only four men in the most favorable time, during the rainy season of Sonora, our animals well rested and in good condition, still it was a difficult undertaking. On our way to the post from Sonoyta we met many emigrants returning from California, men and animals suffering from scarcity of water. Some men had died from thirst, and others were nearly exhausted. Among those we passed between the Colorado and the "Tinajas Altas," was a party composed of one woman and three men, on foot, a pack-horse in wretched condition carrying their all. The men had given up from pure exhaustion and laid down to die; but the woman, animated by love and sympathy, had plodded on over the long road until she reached water, then clambering up the side of the mountain to the highest tinaja, she filled her bota, (a sort of leather flask,) and scarcely stopping to take rest, started back to resuscitate her dying companions. When we met them, she was striding along in advance of the men, animating them by her example.

On our return we had to ride to the "Tinajas Altas," forty-five miles, the first night to reach water; and the second one over sixty-three to "Agua Dulce," where we managed to obtain some by digging. During this time our poor mules plodded through the heavy sand without rest or food.

It was over this country one portion of the new boundary line was to be traced; the road

of which I have just spoken runs immediately along the line, and is the only practicable one connecting California and Sonora.

Before completing the work immediately on the river, a party had been sent out to make a reconnoissance in the direction of the line, and principally to examine the country for water. Anxious to have no delay, as the hot weather was fast coming on, and the river-bottom having become so infested with mosquitoes as to make life unendurable and labor of any kind impracticable, we commenced prolonging the line without awaiting the return of the reconnoitring party. Mr. Phillips, in the performance of this duty, reached the Tinajas, but there found very little water, and what there was, difficult of access; and, although directed to some new water-holes by a Papago Indian, still he only found sufficient to last a short time for a small number of men and animals. Mr. Alemán, of the Mexican commission, also endeavored to travel the road; but meeting the party first sent out, and hearing their report of the entire absence of water from the river to Sonoyta, was compelled to turn back.

The escort and provision train likewise made an attempt, but it was found almost impossible to advance more than a few miles with the heavily-loaded wagons. My own success was little better; starting from our camp with a light spring-wagon and six good mules, I managed to make twenty-five miles in twenty-eight hours' constant travel; an express then reached me from Mr. Alemán, informing me of the unfavorable account of the search for water.

Not finding it feasible to carry out our plan of operations, the parties of both commissions retraced their steps to the Gila. Every effort had been made to prosecute the work, under the most trying circumstances, but we found it useless to contend against impossibilities. It was then agreed by Mr. Jimenez and myself "to cease operations at the west end, and to proceed along the Gila to the east end of the azimuth line, there to fix the point of intersection of the parallel 31° 20′ north latitude with the 111th meridian west of Greenwich, and afterwards to trace the line from that point westward as far as practicable."

On May 5th both parties, American and Mexican, took the road leading up the Gila; this journey was a long and tedious one, our mules having been thoroughly used up in their service on the desert. During the whole winter they had had but scanty grazing, and to find any at all had to be driven ten miles up the Gila. As there are but three or four families of whites living on the Colorado, and those only in charge of ferries, they did not pretend to cultivate the soil and raise grain; and at the post they had only sufficient for their own use. For some little barley, shipped at San Francisco and brought round by water, I paid twelve cents a pound, and for hay one hundred dollars per ton.

The condition of our animals compelled us to make but short marches each day, to enable them to recruit.

As the road we followed has been travelled and reported upon by others, I shall not dwell long upon the subject. It continues the greater part of the distance in the valley of the Gila, occasionally leaving it for a few miles to go upon the sand plains bordering the bottom-land, or where hills jut into the water's edge, such as "Los Metates," "Lomas Negras," or "Lomas del Muerto," either following round their bases or crossing them. The last named is really the only difficult place in the road, but a trying one for mules and wagons. It is 110 miles above Fort Yuma, and consists of steep, rugged buttes, which, in a low stage of the river, can be avoided by crossing to the other side, but in high water must be passed over. Here are several severe ascents and descents, one at an angle of forty-five degrees, where it is necessary to let wagons down by ropes; they are also covered with vesicular rocks, making them exceed-

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PIMO WOMEN.

ingly rough. The valley of this part of the Gila is the same in appearance as that of the Colorado; the soil seems to be more sandy, and contains more alkaline matter; a white efflorescence covers nearly the whole surface. Little grass grows excepting in spots subject to overflow. The same freshet which molested us so much at the initial point here proved a benefit, as we were only able to find grazing where the river had risen over its banks.

I have been told by those who frequently travel along this part of the river, that you may not be fortunate enough once in twenty years to find more than a little bunch-grass, and that only by driving your animals to the plains, four or five miles back from the river. By constant search, we discovered sufficient for our purposes. The growth does not vary much. For the first time, we see the "cereus giganteus," as it rises fifteen or twenty feet above the head.

One hundred and forty miles above the junction we pass a place called "Tezotal." Several miles before reaching it you find limestone rock intermingled with seams of trap. Here the river makes a large bend to the north, and the road pursues a direct course over a *jornada* of forty miles without water, until you reach the Maricopa wells. After leaving these wells you again travel for twenty-nine miles along and occasionally touching the river; you also pass through several Indian villages of the Pimos and Maricopas. The former are further advanced in the art of agriculture, and are surrounded with more comforts, than any uncivilized Indian tribe I have ever seen. Besides being great warriors, they are good husbandmen and farmers, and work laboriously in the field. The women are very industrious, not only attending to their household duties, but they also work superior baskets, cotton blankets, belts, balls, &c. Their huts are very comfortable, being of an oval shape, not very high, built of reeds and mud, and thatched with tule or wheat-straw. They are the owners of fine horses and mules, fat oxen and milch cows, pigs and poultry, and are a wealthy class of Indians.

The Pimos consider themselves the regular descendants of the Aztecs, and claim "Montezuma" to have been of their tribe. One of their legends speaks of his leaving them on horseback on his prilgrimage to found a new country. As the Aztecs in all human probability never saw any horses until their introduction into Mexico by the Spaniards, this seems to be a fabrication. The Aztecs, too, had a form of religious service, but the Pimos to this day have none.

As we journeyed along this portion of the valley of the Gila we found lands fenced in, and irrigated by many miles of acequias, and our eyes were gladdened with the sight of rich fields of wheat ripening for the harvest—a view differing from anything we had seen since leaving the Atlantic States. They grow cotton, sugar, peas, wheat, and corn; from the last two, parched and ground, they make a meal, which, mixed with water, forms a cooling and palatable drink. From the large emigration passing through they have learned the value of American coin, and you can use it in the purchase of anything. Encamping one day at the village of their principal chief, "Cola Azul," a swarm of them soon infested the camp, bringing different articles for sale or barter. In a short time we had laid in a large supply of corn, much needed for our poor worn-out mules.

A little hillock stands near the village, used as a look-out, from which you have a beautiful view of rich cultivated fields. As I sat upon a rock, admiring the scene before me, an old grey-headed Pimo took great pleasure in pointing out the extent of their domains.

They were anxious to know if their rights and titles to lands would be respected by our government, upon learning that their country had become part of the United States.

From the Gila to Tucson—a military colony of the Mexicans on the extreme frontier—is a second jornada, seventy miles in extent. Near the middle of it you pass a detached sierrra called

"Picacho," or peak, an upheaval of volcanic rocks. Tinajas are here found which remain filled with water for short periods after the rainy season.

Several miles before reaching Tucson you strike the bed of the Santa Cruz river, but the stream is subterraneous until you reach the town. The latter is inhabited by a few Mexican troops and their families, together with some tame Apache Indians. It is very prettily situated in a fine fertile valley at the base of the Sierra de Santa Catarina. Some fine fields of wheat and corn were ready for the sickle. Many varieties of fruit and all kinds of vegetables were also to be had, upon which we indulged our long-famished appetites. The Apaches, under the direction of the Mexicans, do most of the labor in the fields.

Circumstances were such that my party and escort were compelled to remain encamped near this town for nearly the entire month of June. During this time we became the recipients of every attention and civility from Captain Garcia, who commanded the place, and from his family. We cannnot find words to express our thanks for their uniform kindness and constant efforts to make the time pass pleasantly.

The month was judiciously occupied in repairing the train and recruiting the mules. Having learned previously on the Gila of the presence of the commissioner and the parties immediately under his charge at his camp near Los Nogales, sixty-nine miles distant from Tucson, my party was directed to stop, while I continued on to have an interview with him.

The road lay in the valley of the Santa Cruz as far as the "Rancho de las Calabasas," between high mountains. On the east are the Santa Catarina, with its top covered with lofty pines, and the Santa Rita rich in minerals; and on the west are the Sierra Rica and the Sierra Atascosa.

A fine specimen of meteoric iron brought from the Santa Rica is to be seen at Tucson, and is used as a blacksmith's anvil. It is massive, and quite malleable.

You pass through the towns of San Javier and Tubac, and the mission of Tomocacari. The first place has been ceded by the Mexicans to the Papago Indians. A beautiful church, with its exterior walls richly ornamented, carved, and stuccoed, and the interior handsomely decorated and painted in bright colors, with many paintings in fresco, still stands as a monument to the zealous labor and religious enthusiasm of the Jesuits of the past century.

Tubac is a deserted village. The wild Apache lords it over this region, and the timid husbandman dare not return to his home.

The mission of Tomocacari, another fine structure of the mother church, stands, too, in the midst of rich fields; but fear prevents its habitation, save by two or three Germans, who have wandered from their distant fatherland to this out of the way country.

Leaving the Santa Cruz river at the rancho, and following up the pretty little valley of Los Nogales for several miles, brought me to the camp of the United States commissioner. It was a gratifying sight, and refreshing to the senses, as I traversed these valleys, to see them clothed with rich green verdure, and contrast them with the bleached barrenness of the Colorado and Gila.

On my arrival, I found the observations for determining the latitude and longitude of the intersection of the parallel and meridian nearly completed, under the order of the United States commissioner, and, a short time after, a pyramidal monument of dressed stone was erected to mark its position. At this point Mr. Jimenez and myself again commenced operations, on the 26th of June, to trace and mark the azimuth line running westward. By this time there were some indications of the commencement of the rainy reason, for which we had been anxiously waiting. At any other period of the year it would have been impossible to attempt this section of the work,

as there is little or no permanent water in the neighborhood of or along the whole length of this line of two hundred and thirty-seven miles.

Whilst the work was progressing, Lieut. Patterson moved with the escort and train from Tucson, via Tubac and Sopori, to Aribaca. Ojo del Agua de Sopori is a spring, twelve miles from Tubac, in a westerly direction; it once irrigated the valley of the same name, which was cultivated by Mexicans. We found a solitary peach tree, loaded with fruit, and signs of acequias, relics of other days. The stream is a small and pretty one. A league from it, in the Sierra Atascosa, rich mines of copper, silver, and gold, are said to exist. Its mineral resources have not yet been thoroughly examined, on account of the Apache Indians. Only the night before reaching "Sopori," a large party of them passed within a short distance of our camp, driving before them a drove of horses and mules. Within a day's ride of Tubac, through the "Sonora Pass," they have large herds of these, together with cattle and milch cows.

Eighteen miles and a half from "Sopori" (an Indian name) you reach a deserted Mexican rancho, in the valley of Aribaca; the latter is narrow, lying east and west, and bounded by high granite hills, limited on the east by the Sierra del Pais. These are all said to be rich in mineral wealth. Within four miles, and south of the deserted rancho, are to be found large excavations made by men previously engaged in mining; piles of metallic ore lay near the springs where they had been engaged in smelting.

The valley was mantled with rich green pasturage; immediately bordering it are hills covered with fine grama grass and a low growth of mezquite. Numerous springs lie concealed among the tule, with here and there a willow or a cotton-wood to mark their localities. A mule trail runs south from this place to Tubutama, a small town in Sonora, crossing the line about thirteen miles from Aribaca, and within four miles of the "Ojos Escondidos," lying at the base of the sierra of that name. To the northwest is a range of mountains crowned with a high peak of solid rock, called by the Papago Indians "Baboquivari," or "Water on the Mountain;" in winter it is covered with snow and ice, although at its base lies the "Tierra Caliente." It is a most prominent and unmistakeable land-mark, and during the triangulation of the line was of the greatest service, as it could be seen from different points more than one hundred miles apart.

The main escort and train remained in camp at Aribaca until near the middle of August. A few men, under Mr. C. Michler, were sent west to Sonoyta with supplies to re-provision the party on the line, and to make a reconnoissance of the road made by the wagons from Tubac to that place. Lieutenant Closson, with twelve men, formed their escort. Mr. Jiminez and Mr. Alemân accompanied them, for the purpose of going to Quitobaquita to establish its astronomical position, according to agreement entered into with the United States commissioner.

The sierras to the west were reported to be detached, and not continuous, so that, by winding around their bases, a good, although circuitous wagon road might be found; between them are generally broad and level valleys. The heavy rains in that direction offered great hopes of an abundance of water on the road.

Having shown the movements of the different parties, I return to the party on the line. This was necessarily very small on account of the anticipated scarcity of water. To reduce as much as possible the size of the pack-train, there were no more men employed than were absolutely necessary to do the work, without any regard to protection or defence against the Indians.

Leaving the "Potrero" in the valley of Los Nogales, where my party had been encamped for a few days, we started for the monument at the intersection of the parallel 31° 20′, and the

111th meridian. Our trail led up a pretty little valley towards the west for eight miles, when we reached the base of the "Sierra de los Pajaritos" (the Mountain of Little Birds;) following up one of the arroyos or gullies of this chain, we were soon locked in on all sides by high hills; the ravine through which we continued to wind for four miles became rocky, narrow, and difficult to pass, until we reached some small springs, "Los Ojos de Alizos." At this point we left the arroyo, and by clambering up a steep ascent gained the crest of the hills; riding or walking along it as best we could, and passing from hill to hill, each higher as we advanced, we finally reached the point where the monument stands. The hill on the side of which it is erected is low compared to the high peaks in its immediate vicinity; its locality is not easily discovered. Our instrument being placed in position, the azimuth of the new line (69° 19′ 45.9″ northwest) was measured from a meridian established by assistant Clark; a large live-oak growing on the adjoining ridge was found to be in the direction of the line, and answered the purpose of a monument, (No. XIX from the Rio Colorado.) Señor A. Diaz, with a party, operated conjointly with us in the prolongation of this line.

As if in response to our earnest wishes for rain, to be able to continue the work, we had scarcely commenced our labors before the heavens poured down refreshing showers, which we saw with pleasure extended along the line. The commencement of the rainy season is in reality the beginning of spring. The vegetation during the actual months of spring and summer is so parched by the excessively hot suns, that the country present the same appearance as is produced by the effects of frost in our more northern climates. The seeds seem to rest in the earlier part of the season, in order to germinate and beautify the autumn and winter.

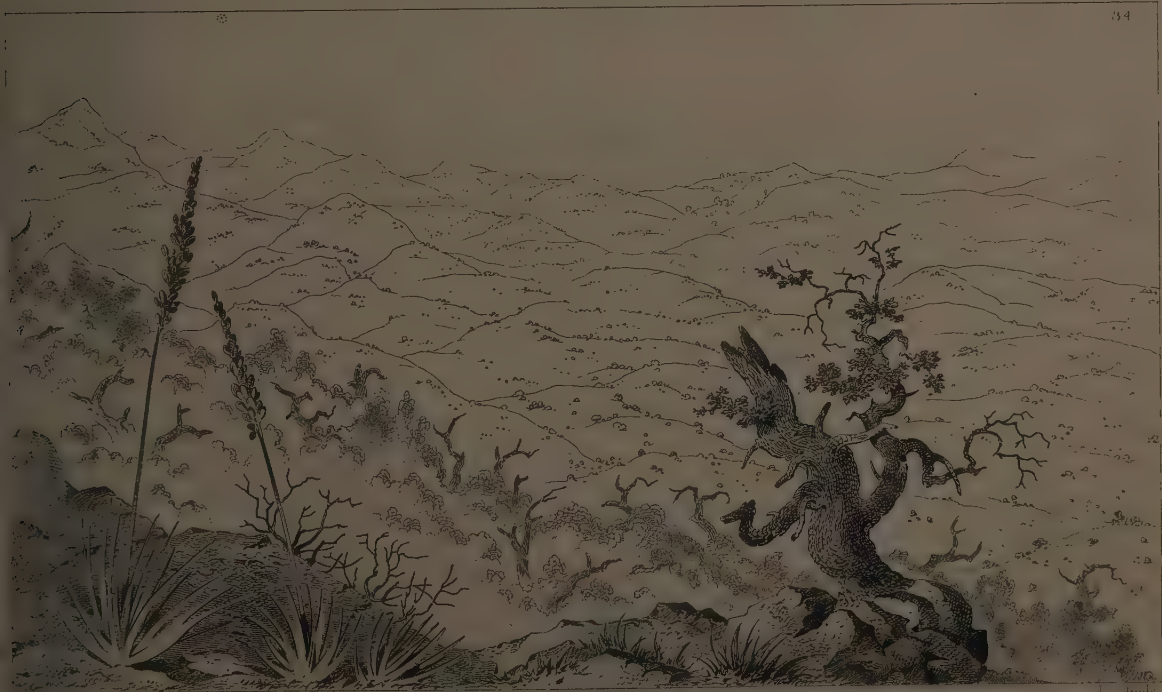
"The Sierra de los Pajaritos" is said to form part of the Arizone mountains, reported to be the richest in Mexico. Many specimens of copper, gold and silver are found on the surface, and they are no doubt rich in ore. The hills are covered with live-oak trees, and are overspread with a rich growth of grama grass; they are capped by masses of conglomerate rocks. Monument XVIII, distant from XIX, a little over three miles, is situated on the same sierra.

The country here presents a new aspect. Powerful volcanic irruptions have at some earlier period of the world's history produced great disturbances in this part of the earth. Strata of limestone once horizontal, are now curved and bent by the force of this action, and masses of igneous rocks have been upheaved through the fissures opened on the surface. Here you find granite rocks, and near them beds of trap; and not far from both, limestone; then again all fused in one conglomeration. It was impossible to approach the station nearer than three miles with the riding and pack mules; the instruments had to be transported by hand for that distance up a rugged hill covered with vesicular and scoriaceous rocks.

Monument XVII is placed on the "Sierra de Sonora," seventeen miles from XVIII. Three days were occupied in travelling this short distance. The trail for the first two was over almost impassable mountains; massive rocks and steep precipices constantly impeded the progress of and turned the party out of its course, making the route circuitous as well as hazardous; rough ascents were surmounted, steep ravines followed down, and deep gullies passed; the mules had actually to be dragged along.

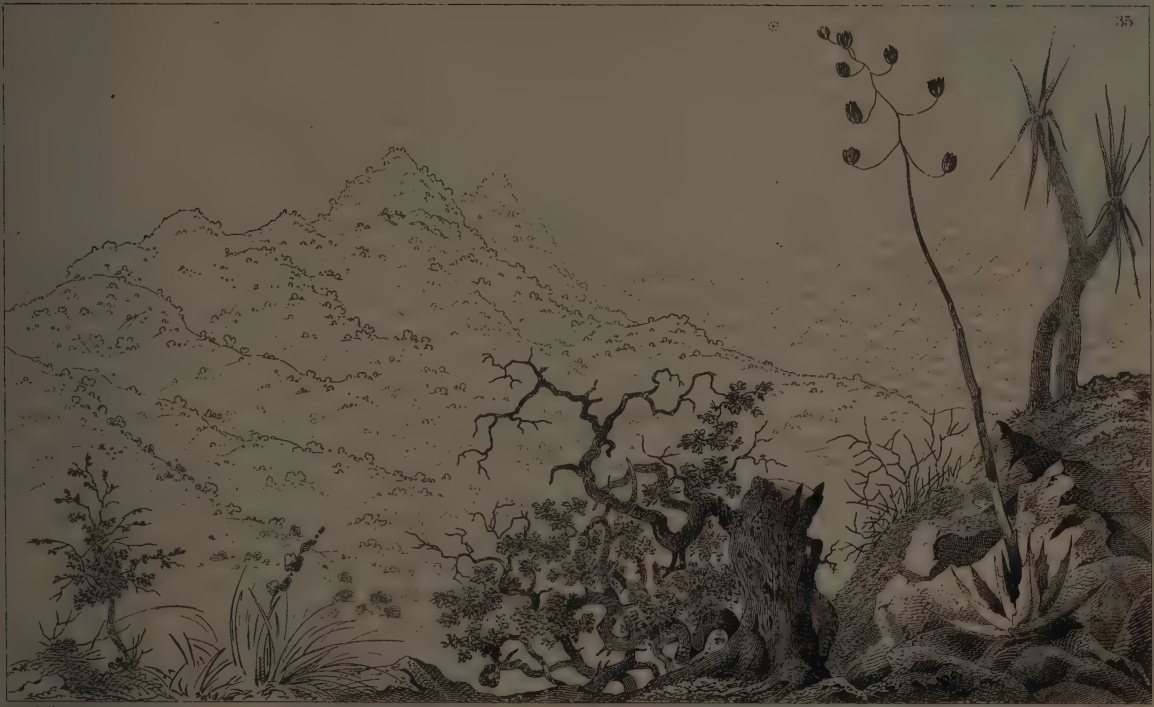
At the end of the second day the party found some small springs—"Los Ojos Escondidos"—on the trail to Tubutama, and encamped on them. On the third, the trail was still over high hills, but not so difficult; and some springs—"Los Ojos de Granizo"—a short distance from the monument, were reached. The animals had become so injured and lame by the sharp angular rocks, that they had to be taken into Aribaca to be reshod, and many of them to be replaced by others.

VIEW FROM MONUMENT Nº XIX, ON THE SIERRA DEL PAJARITO, LOOKING EAST TOWARDS THE MONUMENT AT THE INTERSECTION OF 111TH MERIDIAN AND PARALLEL 31°. 20′ NORTH.



VIEW FROM MONUMENT Nº XIX, LOOKING WEST TOWARDS MONUMENT Nº XVIII, IN THE PUERTO DE LA SIERRA DEL PAJARITO.

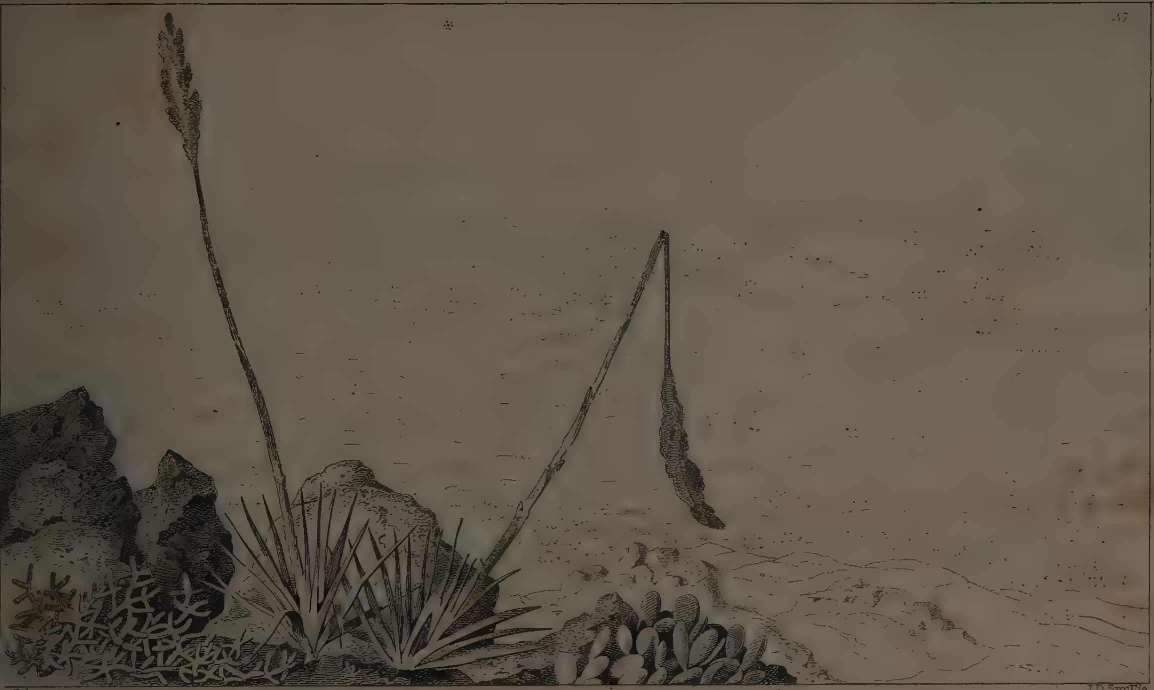
35



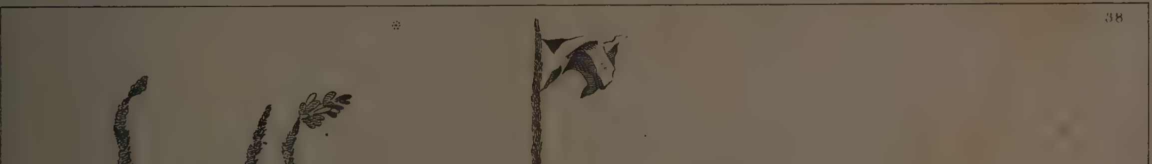
VIEW FROM MONUMENT XVIII [illegible] LA [illegible] XII [illegible] SONORA

36

[illegible] MONUMENT XXI [illegible] LA [illegible] MONUMENT XIX



VIEW FROM MONUMENT Nº XVII, ON THE CERRO DE SONORA, LOOKING WEST TOWARDS MONUMENT Nº XV. ON THE SIERRA D'EL POZO VERDE.



VIEW FROM MONUMENT Nº XVII, LOOKING EAST TOWARDS MONUMENT Nº XVIII.

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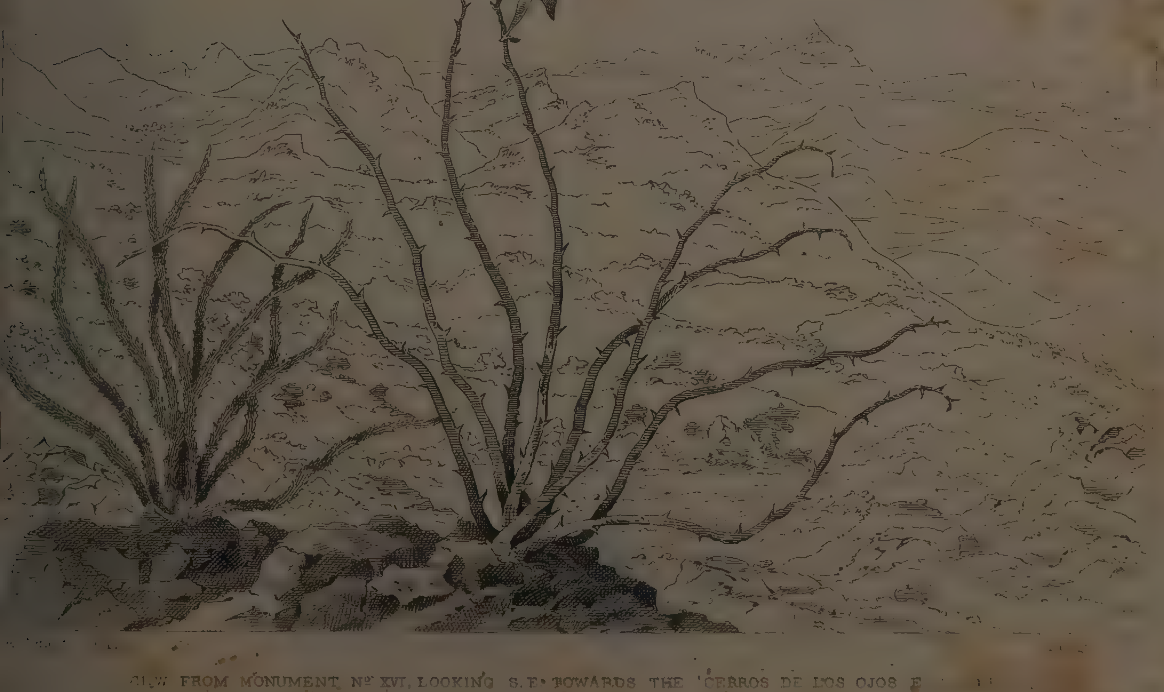
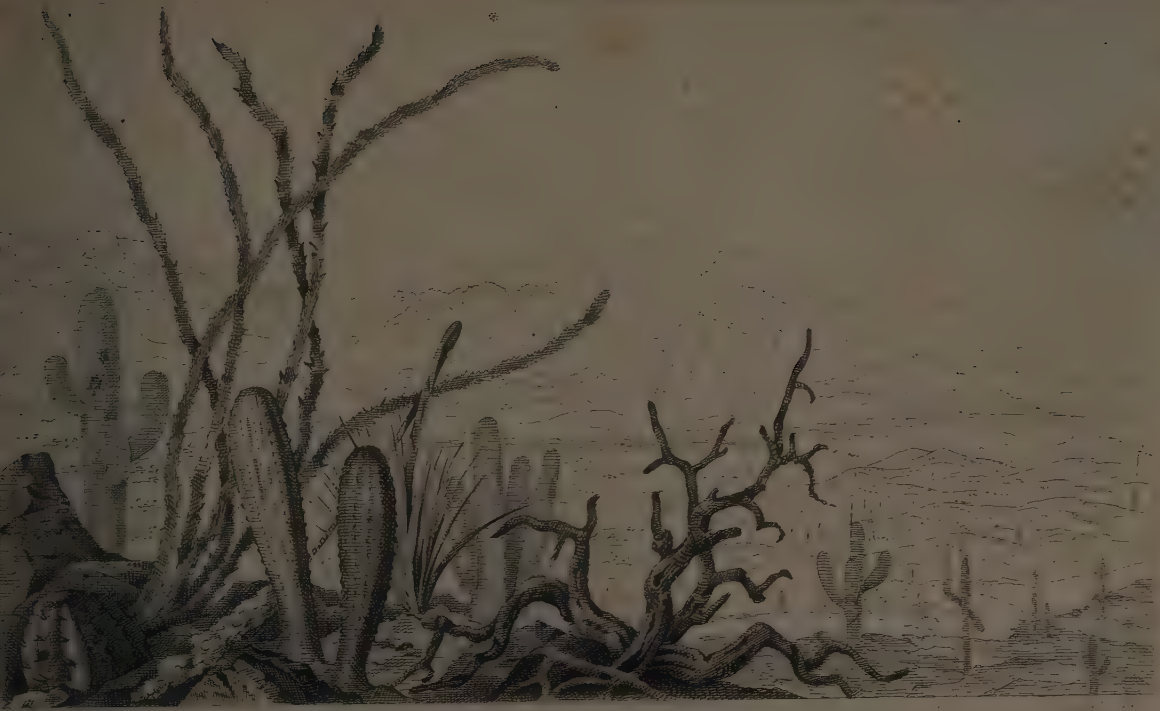
VIEW FROM LINE (½ MILE WEST OF MONUMENT Nº XVI,) LOOKING N.W. TOWARDS 'BABUQUIBARI'.



[illegible]W FROM MONUMENT Nº XVI, LOOKING S.E. TOWARDS THE 'CERROS DE LOS OJOS [illegible]



VIEW FROM MONUMENT Nº XV ON THE 'SIERRA VERDE' LOOKING EAST TOWARDS MONUMENTS XIV, XIII & XII.

VIEW FROM MONUMENT Nº XV LOOKING WEST TOWARDS MONUMENT Nº XVI

VIEW FROM MONUMENT Nº XIV, ON THE SIERRA DE LA UNION LOOKING EAST TOWARDS MONUMENT Nº XV

VIEW FROM MONUMENT Nº XIV, LOOKING WEST TOWARDS MONUMENT Nº X

48

A. Schott Del — Dougal Sc

VIEW FROM MONUMENT Nº XIII NEAR SIERRA DE COBOTA, LOOKING EAST TOWARDS MONUMENT Nº XIV

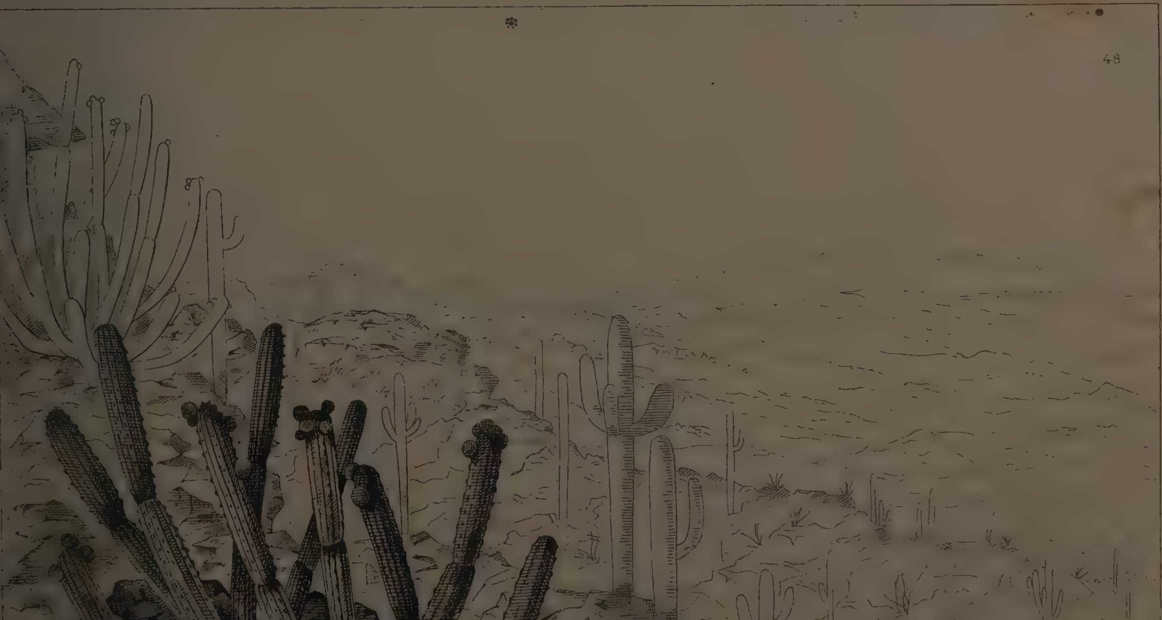
49

A. Schott Del — Dougal Sc

VIEW FROM MONUMENT Nº XIII LOOKING WEST TOWARDS MONUMENT Nº XII

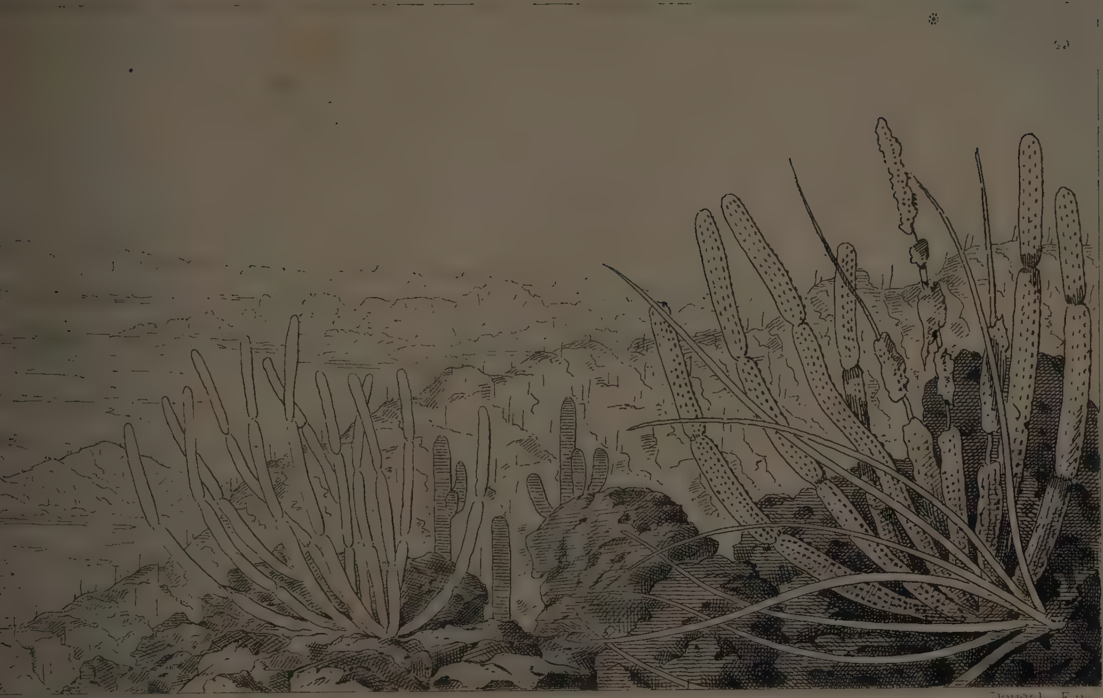
A. Schott Del. Dougal En.

VIEW FROM MONUMENT Nº XII ON THE EAST RIDGE OF SIERRA DE LA NARIZ, LOOKING EAST TOWARDS MONUMENT Nº XIV.



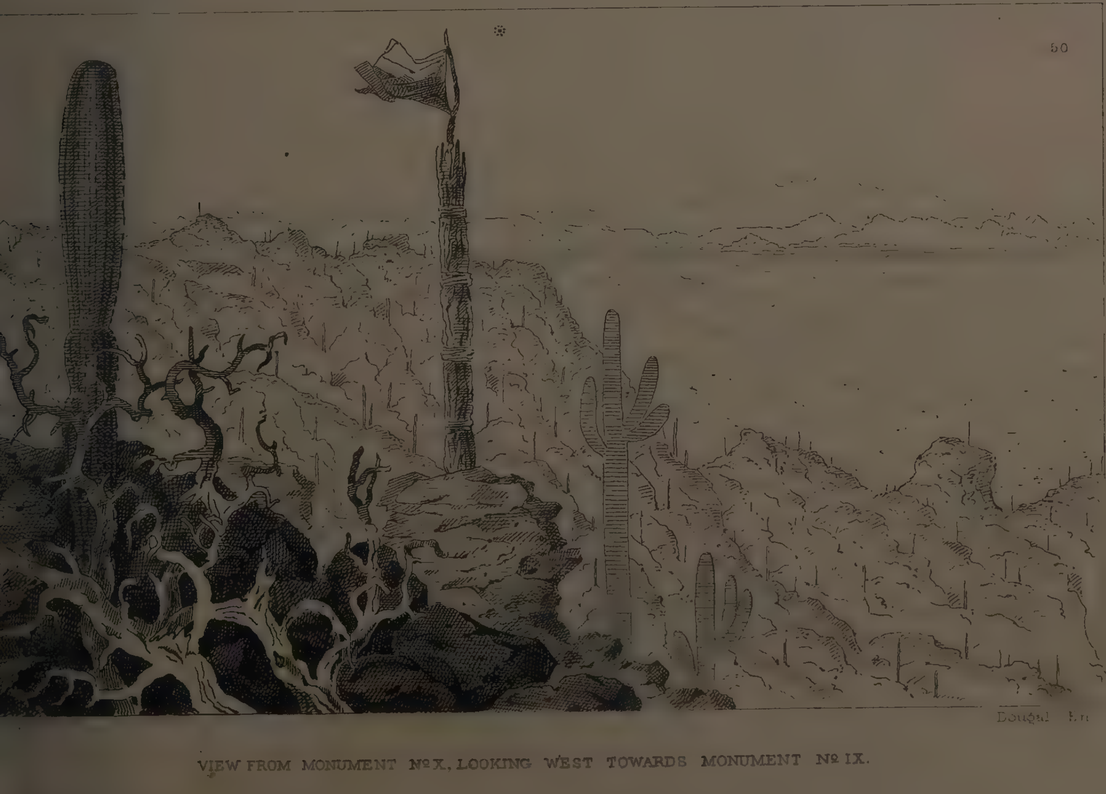
Dougal En.

VIEW FROM MONUMENT Nº XII LOOKING WEST TOWARDS MONUMENT Nº X



Dougal En

VIEW FROM MONUMENT No X, ON THE WEST RIDGE OF SIERRA DE LA NARIZ, LOOKING EAST TOWARDS MONUMENT No XII.



Dougal En

VIEW FROM MONUMENT No X, LOOKING WEST TOWARDS MONUMENT No IX.

51

Dougal En.

VIEW FROM MONUMENT No. IX, ON THE SIERRA DE SONOYTA, LOOKING EAST TOWARDS MONUMENT No. X.

52

VIEW FROM MONUMENT No. IX, LOOKING WEST TOWARDS MONUMENTS VIII, VII, VI & V

Dougal En.

VIEW FROM MONUMENT Nº VIII, NEAR 'LOS OJOS DE QUITOBAQUITA', LOOKING EAST TOWARDS MONUMENT Nº IX.

Dougal En.

VIEW FROM MONUMENT Nº VIII, LOOKING WEST TOWARDS MONUMENTS Nºs VII & VI.

VIEW FROM MONUMENT Nº VI, ON THE 'CUCHILLA DE LAS CHOYAS', LOOKING EAST TOWARDS MONUMENT Nº IX

VIEW FROM MONUMENT Nº VI, LOOKING WEST TOWARDS MONUMENT Nº V

57.

... FROM MONUMENT Nº V, ON THE SIERRA DEL TULE, LOOKING WEST TOWARDS MONUMENT Nº IV

58.

[illegible]

59.

VIEW FROM MONUMENT Nº IV ON THE SIERRA DE LAS TINAJAS ALTAS, LOOKING EAST TOWARDS MONUMENT Nº V

60.

VIEW FROM MONUMENT Nº IV LOOKING WEST TOWARDS MONUMENT Nº III

VIEW FROM IRON MONUMENT Nº II, NEAR THE EDGE OF THE COLORADO DESERT LOOKING EAST TOWARDS MONUMENT Nº IV

VIEW FROM IRON MONUMENT Nº II, LOOKING SOUTH WEST TOWARDS THE CORDILLERAS OF LOWER CALIFORNIA.

63

A. Schott del.

J. D. Smil...

VIEW FROM THE INITIAL POINT OF AZIMUTH LINE ON THE RIO COLORADO DEL OESTE, LOOKING NORTH TOWARDS "AVIE-MIL-LI-KET" OR "SIERRA DE SAN PABLO."

64

A. [illegible] del.

VIEW FROM YUMA HILLS BELOW THE JUNCTION OF THE COLORADO AND GILA LOOKING EAST TOWARDS SIERRA DE SAN PEDRO, OR [illegible]

A few feet south of the line is a prominent peak of the "Sierra de Sonora," which serves as a good natural object to mark it. A league from it are "Los Ojos de Granizo," (Springs of Hail;) their position is indicated by Monument XVI, erected on a hill two hundred metres to the north of them, as well as by some few willow and other trees. The soil is very rich in their neighborhood; the vegetation is profuse, and there is an abundance of fine grama grass; live-oak, and occasionally cedar, are seen on the hills. Whilst encamped here, heavy storms of wind, hail, and rain, were experienced; the valley where the party lay was so quickly flooded as to endanger all the camp equipage, as well as instruments; tents were blown down, and many articles carried away by the hurricane. Notwithstanding the inconvenience attending them, the rains were welcome, as they refreshed and cooled the atmosphere, which was oftentimes heated to 110° Fahrenheit. Some strange specimens of natural history were found at this place; among them, what is called by the Mexicans "El Scorpion," a large, slothful lizard, in shape a miniature alligator, marked with red, black, and white belts—a hideous-looking animal. The *alicante* and *coralilla* snakes were also caught, and added to the collection of natural history.

Leaving Los Ojos de Granizo, our trail lay over a wide and rich valley, running north and south, and extending along the east base of the "Sierra Babuquivari." Crossing it, brings you to the base of "Sierra del Pozo Verde," on which is erected Monument XV, a little more than nine miles from XVI. A trail leads round its southern extremity to Agua del Pozo Verde, (Green Well,) lying at the foot of the western slope, a little east of south, and about two miles distant from the monument. Permanent water is found here; and, although a large number of animals soon exhaust it, still it fills up in a very few hours. This is the site of an old rancheria of the Papago Indians. Numerous "metates" for grinding corn are lying about. The grave of one of their chiefs, who had been killed by the Apaches, was found near camp. A thousand arrows were buried with him, placed there as a token that his death would be avenged by his tribe. The Indians respect these graves, and the deadly threats which they contain, and will not remove a single arrow from the number, although it is a warning of hate and hostility.

The "Sierra del Pozo Verde" is very high, and overlooks wide valleys east and west of it. It is of granitic formation, and covered with a rich growth of grass, and plants of various kinds. The *suwarrow* grows on it in abundance; also the Fonquiera and many varieties of cacti, bearing beautiful flowers. The fruit of the suwarrow is delightful; it is shaped like the pomegranate, and when opened, presents the same beautiful carnation red; the seeds are very small and numerous, and of a black color; only the pulp and seeds are eaten. The Pimos and Papagos use it for food; also a small white cactus, which just peeps above the ground. Many antelope were seen about this place. The glare of our fires attracted a large number of rattlesnakes; the whole place seemed infested with them. We judged them to be a new species from their tiger-colored skins; they were exceedingly fierce and venomous. On the deserts of the Colorado we had often seen others with horns, or small protuberances above the eyes; and Dr. Abbott had taken from the body of still another species quite a number of small ones, among which was a monstrosity with two perfectly formed heads attached to one neck. When you lie down on your blankets, stretched on the ground, you know not what strange bedfellow you may have when you awake in the morning. My servant insisted upon encircling my bed with a reata of horse-hair to protect me from their intrusions. Snakes are said to have a perfect r pugnance to being pricked by the extremities of the hair. The paisano, or

chapparal cock, surrounds his antagonist, while asleep, with a chain of cactus thorns; when the preparations are all made the bird flutters over the head of the snake to arouse it to action; the latter, in its vain efforts to escape, is irritated to such a degree, by running against the barrier encompassing it, that it ends its existence by burying its fangs in its own body.

From Sierra del Pozo Verde we moved on to Monument XIV, on the "Sierra de la Union," sixteen miles and a half from the last. The country between the two sierras was, as usual, a broad plain; but there is a great contrast between the east and west portions; the first seven miles were exceedingly rich, and covered with a fine growth of mezquite grass and underbrush, but the remainder of the distance was entirely bare of any kind of vegetation until we reached the base of the mountains, where we found the usual growth of palo verde, palo de fierro, cacti, &c. The bleached appearance of the soil, together with the excessive heat of the sun, reminded us of the Colorado desert.

The sierra is of igneous origin, with a considerable mixture of lime. Its western slope, instead of having the arid and desolate appearance of the eastern one, was fresh and green. Crossing it, we encamped at its base, near "Los Ojos de Yestas."

The next monument, XIII, is placed at the point of intersection of the line and the road made by the few wagons previously sent to Sonoyta, and not far distant from the "Papago Rancheria de Cobota." It is 11.8 miles from Monument XIV, and stands in a valley, limited by the Sierra de la Union and the "Cerritos de los Linderos." The boundary runs a few feet south of a high peak of the former, and between two prominent horns of the latter, both positions making good natural points of reference. This valley resembles the last in every respect. A deep gap in the mountain, near the Cerritos, affords a good pass, and the trail then goes out upon a broad plain, bounded on the west by the "Sierra de la Nariz," (Mountain of the Nose.) This plain is nearly level, and covered with low mezquite, and a few withered plants; its white surface, perfectly destitute of grass or of any verdure, gives it a dismal appearance. There is no water except in charcos, or ponds, filled by drainage after heavy rains. The same description answers for the country west of the Sierra de la Nariz, in the prolongation of the line, until you strike the valley of Sonoyta. Monuments were erected along this portion of the boundary, as follows:

No. XII, on the east ridge of Sierra de la Nariz; No. X, on the west ridge; and No. XI, on the wagon road made by our supply train, passing along the narrow valley between the two; from XIII to XII is 27.70 miles; XII to X, 4.3 miles.

These mountains are masses of black igneous rock, and difficult to clamber up. The eastern slopes are gradual, but the western are perpendicular ledges.

Monument No. IX stands on the Sierra de Sonoyta, 14.5 miles from X, and about one mile and a half north from the town of Sonoyta.

We found encamped near Sonoyta, the small party sent forward with provisions. Their road had been a circuitous and a hard one. The sierras had proved disconnected, and running in parallel ridges from northwest to southeast, with small valleys between them. Not being able to pass with wagons through the rough gaps frequently occurring in the mountains, they managed to wind round the bases, which are short and abrupt. A westerly course was preserved as much as the nature of the country would permit. Only a few small springs were discovered, and but one large well, regularly walled in by the Indians at Cobota. Had it not been for the heavy showers which fell almost every day, it would have been impossible for the

Arthur Schott del.

Lith. of SARONY, MAJOR & KNAPP, New York

PAPAGOS

Arthur Schott del.

lith. of Sarony & C° New York

ARENEÑOS
SUBTRIBE OF THE PAPAGOS.

party to have found sufficient water to supply their wants. At the time we reached there, Mr. Jimenez was engaged in observing for latitude and longitude at Quitobaquita.

The valley of Sonoyta is not very wide, but affords pasturage for large numbers of cattle. Numerous springs course through it for short distances, and then sink into subterraneous channels. These, together with the "Ojos Escondidos," "Pozo Verde," the well at Cobota, and the springs at Quitobaquita, furnish the only water on the line that can be relied upon; nor are these always sure, as experience taught us. There is no timber within several miles of the settlement; firewood has to be brought on the back of the patient *burro.*

The town of Sonoyta is the door of the State of Sonora, from the California side. It is a resort for smugglers, and a den for a number of low, abandoned Americans, who have been compelled to fly from justice. Some few Mexican rancheros had their cattle in the valley near by. It is a miserable poverty-stricken place, and contrasts strangely with the comparative comfort of an Indian village of Papagos within sight.

The Papagos wander over the country from San Javier as far west as the Tinajas Altas. They were at one time a formidable tribe, and waged unceasing war against the Mexicans. Having sustained repeated losses, they at length sought their God, who is said to dwell upon the high peak of Babuquivari, to ask his aid and countenance in their last grand fight with their enemies. They assembled their families and herds of horses and cattle within an amphitheatre enclosed by the mountain ridges, and battled it manfully for many days at its entrance; but their God could not turn the fate of war, and they suffered an overpowering defeat; since that time they have been quiet and peaceable.

We passed many deserted Papago rancherias; they are generally situated some distance from water, as there seems to be a superstition about living near it; the women, who do all the labor, have to bring it in ollas, or earthen vessels, a long way, bearing it on their heads; they are compelled to keep very large ones filled, which are sunk in the ground, and capable of holding a great many gallons. This tribe is comparatively well off in worldly goods; they plant and grow corn and wheat, and possess cattle, and many fine horses. Nature supplies them with numerous useful plants which grow spontaneously; from the suwarrow (Cereus Giganteus) and pitaya they make an excellent preserve by simply boiling the fruit down without sugar, and also a candy of the same material. They collect from a low bush growing wild, seeds called "Chie," which are coated with a gummy substance; placed in water these become partly dissolved, and make a cool and refreshing drink, a refreshment much needed in that warm country. The women are better dressed than most Indian women; they all wear skirts of manta or calico, covering the body from the hips down. They appear to be a good, quiet, and inoffensive tribe. A sub-tribe of the Papagos, called Areneños, live on the salt lakes near the Gulf of California, and principally subsist upon fish.

North of Sonoyta, and about forty miles distant, is a rugged serrated range of mountains called "Sierra del Ajo," represented to be rich in copper, gold and silver. A company was engaged in attempts at mining, but, from the scarcity of water, with little hopes of success. The great distance necessary to transport the ore on pack-mules before reaching navigation, will render their efforts futile and unprofitable.

The section west from Sonoyta to the Colorado has already been described. In August we were enabled to complete that portion of the work, and although engaged upon it during the wet season, barely sufficient water was to be had for our wants. The heat had become so great as to compel us to operate entirely with signal-fires by night. Monuments are placed near Quitobaquita, Agua

Dulce, Tule, and Tinajas Altas, to mark the boundary. The line runs a few feet south of the springs at Quitobaquita, north of Agua Dulce and Agua Salada, and south of the Tinajas del Tule and Tinajas Altas. The sierras on which these two last are located were troublesome to work on; their summits are so peaked as to make it difficult to find a place sufficiently large upon which to stand or place an instrument. Those who visited these stations to determine them, had to console themselves by sitting up all night after their work was done, as there was not sufficient space to stretch themselves out.

The big horn mountain goats frequent this region, and the noise of their horns as they butt them together in fight is often heard among the rocks.

Mr. Schott has made a large and interesting collection of botanical plants and of natural history, besides making careful examinations of the geology of the country; he has also taken the views of the scenery along the line, which accompany this report.

It was a happy day that witnessed the termination of the field-work. On the 25th of August both parties left Sonoyta for Altar, and thence via Santa Anna to Magdalena, in the State of Sonora. The tracing and marking and triangulation of the line having been completed, Mr. Jimenez and myself compared at this last place the data for fixing the respective distances between stations, and the positions of the prominent topographical features of the country.

The section marked "B," (see Astronomical and Geodetical work,) shows the results of calculations of the latitudes and longitudes of points in the triangulation made to determine the "azimuth line of twenty English miles," together with tables showing the lengths of iron rods, A and B, used for measuring the base line; tables for laying off the circumference of the circle having its centre at the junction of the Gila and Colorado, and radius of twenty miles; tabulation of results for the latitude of the initial point on the Colorado; astronomical determinations of positions on the azimuth line between the Colorado and 111th meridian; and distances between monuments. Tabulated distances along the routes in the neighborhood of the boundary line from the Pacific ocean to the Gulf of Mexico also accompany this report.

At Imuris, a few miles from Magdalena, we found Lieutenant Patterson, encamped with the escort and train, having left Aribaca in August, and reached there via Tubac and Los Nogales. When at this last place, the Apaches, splendidly mounted upon fine horses, made a descent upon his animals and endeavored to stampede them. Although the Indians, in war-dress and uttering unearthly yells, dashed up within fifteen feet of the mules, then in excellent condition and well-rested, still their efforts were unsuccessful.

At Imuris the parties of both commissions separated—the one to return to the city of Mexico, the other to cross the continent to the Gulf of Mexico, and thence to Washington city.

I take great pleasure in reporting to the commissioner the very agreeable relations, both official and social, which constantly existed during a difficult work, with those gentlemen of the Mexican commission with whom we were so long and intimately associated.

From Imuris we travelled the road up the San Ignacio river by Cocospera, a deserted mission, to the rancho de San Lazaro, where we struck the main southern emigrant road. If space permitted, I should like to dwell upon the rich valleys of the "Tierra Caliente" of Sonora, the towns of Altar, Santa Anna, Magdalena, Imuris, San Ignacio, and Cocospera, through which we journeyed on our way home; upon their highly cultivated fields of grain and sugar-cane, irrigated by miles of acequias, and their gardens loaded with richly flavored fruit of the tropics as well as of the more temperate zones. At Magdalena we saw in the same garden, apples, peaches, apricots, pomegranates, figs, grapes, lemons and oranges. Leaving San Lazaro, we followed the

road, via Santa Cruz, Janos, and Corralitos, to El Paso, and thence took the southern route through Texas to San Antonio de Bexar. From San Diego, on the Pacific ocean, via Fort Yuma, Tucson, Santa Cruz, Janos, El Paso, and San Antonio, to Indianola, on the Gulf of Mexico, measured by viameter, the distance is 1,727.32 miles. From San Diego, via Fort Yuma, Sonoyta, Altar, Imuris, Santa Cruz, Janos, El Paso, and San Antonio, to Indianola, the distance is 1,695.22 miles.*

My party arrived at this place November 30, 1855; a few days after, it was discharged, and the property belonging to the commission disposed of by sales. I reached Washington January 10, 1856.

To the officers of my escort, and to my assistants, I feel deeply indebted for their urbanity in all my companionship with them, and for their untiring efforts in the performance of their duties.

I am, sir, very respectfully, your obedient servant,

N. MICHLER,
Lieut. Corps Top. Engineers, U. S. Army.

Major W. H. EMORY, U. S. A.,
U. S. Commissioner.

RECONNOISSANCE TO THE MOUTH OF THE GILA RIVER, FROM SAN DIEGO, CALIFORNIA, SEPTEMBER 11 TO DECEMBER 10, 1849.—BY C. C. PARRY, M. D.

On the 11th September, 1849, the astronomical party of the United States boundary commission, detailed by Major W. H. Emory for the determination of the point of junction of the Gila and Colorado rivers, left the Mission San Diego, en route across the mountains.

A more direct course than that usually taken was concluded on, leading northeast by the Rancho Santa Monica, to intersect the road usually travelled at Santa Maria.

Soon after leaving the mission grounds, we commence the ascent of the first rocky range, leading by steep slopes to a height of several hundred feet above the river valley; thence, passing over upland terraced plains, to descend a broken slope on the opposite (eastern) side.

The rock exposures show a form of porphyritic greenstone, of close, compact texture, and uniform bluish color. As exposed in the line of the river course, which lies to our left, it exhibits abrupt broken walls, through which the river makes its way, forming, near its exit from the range, a distinct fall of ten or twelve feet in a distance of two hundred yards. At this point commences the line of irrigating ditch, which formerly supplied the cultivated grounds adjoining the Mission of San Diego, distant two miles or more. The only traces of this aqueduct now remaining consist of broken patches of masonry, seen at several points along the right bank of the stream.

This greenstone range, having an average width of two to five miles, terminates on the east in an open basin valley, bounded on its western aspect by granite rocks, whose grey, mottled appearance shows a marked contrast to the uniform bluish aspect of the porphyry range.

Our route thence, observing a general northeast course, passes diagonally over the wide basin-valley below, reaching, at a distance of twelve miles from the mission, the Rancho Santa Monica. This rancho occupies the left bank of the upper San Diego river, attached to which is a very considerable section of rich bottom-land, capable of irrigation. The higher lands, and mountain slopes adjoining, furnish the requisite pasture ground to extensive herds of cattle and

* The distance can be shortened and the road improved by following the line of Lieutenant Parke's exploration through the new territory. W. H. E.

horses. From this point, continuing a northeast course, the main stream of the San Diego river is crossed; thence you pass up a more northerly branch. On this route we soon approach an immense mountain wall, lying on our right, and blocking up our way eastward. The ascent of this was accomplished at a depressed point in the general range, leading by a rude, unbroken track along the edges of a ravine. The general height of the ridge, some eight hundred feet above the valley, was at last attained by doubling teams, and frequent manual assistance.

Our route thence led along, and beyond, the line of broken valleys and irregular ridges, showing frequently depressed basins, over upland plains, to the Rancho Santa Maria. The rock exposure was quite uniform, being composed of crystalline feldspathic granite, coarsely grained, or showing occasionally a close sienitic texture. The computed height of the Rancho Santa Maria, above the sea, is 1,353 feet. It occupies the western edge of an extensive upland plain, from which is distinctly visible towards the east, at a distance of fifteen to twenty miles, the broken line of the dividing ridge of this mountain range.

On the northern border of this plain lies the lower course of the Rio Santa Isabel, flowing hence in an irregular western course, and finally forming the San Diegito river, which empties into the ocean some twenty miles above San Diego. The open plain is destitute of timber, being covered mainly with pasture growth. The California live-oak (Quercus agrifolia) grows on all the adjoining mountain slopes. Continuing along the line of the main road to Santa Isabel, being the same followed by General Kearny in 1846, the day before the battle of San Pasqual, a gradually increasing elevation brings us in the midst of the attractive mountain scenery of this portion of California. We here pass amid groves of live-oak, verdant shrubbery, and rich pasturage, set off in the back-ground by high rocky cliffs, or disclosing, in the distance, pine-fringed heights, distinctly marked against the clear sky. At Santa Isabel we encounter a clear running stream, coursing through an open valley, surrounded by lofty mountains; those directly to the east form the dividing crest of the range.

From this point there is a "cut-off" leading by a direct east course, over the mountain ridge, which rejoins the wagon road at San Felipe. To this route, being least known, we shall confine our remarks. Passing then directly up the main course of the Rio Santa Isabel, we follow a plain bridle-path, which, passing by frequent ascents, at first steep and broken, amid rocky exposures of granite, soon expands into quite an open valley. This valley is bounded on either side by steep mountains, along the sides of which, as we proceed upwards, pines make their appearance. Our trail, crossing from one side to another of the lively brook dignified with the title of the Rio Santa Isabel, brings us into the main road, about six miles above the settlements, and near the dividing crest of the main ridge. Just below this is situated the rancho of a Mr. Williams. The country here has a fresh mountain look; the air is cool and bracing. The rock exposures at this point show a form of quartz granite, frequently imbedding crystals of tourmaline.

The view from the higher peaks in this vicinity, reaching probably a height of 5,000 feet or more above the sea, is strikingly grand. We here overlook, to the westward, the broken mountain ranges stretching in a dim line seaward; to the east the descent is more abrupt, and the view shows the bare outline of the desert mountains, projecting in irregular spurs into the desert plain, or standing as isolated ridges in the dull brown expanse below.

The descent from the ridge to the east is by abrupt pitches along the sides of a steep ravine, opening out below into a dry waterless valley; this valley, thence expanding, forms the open plain of San Felipe, surrounded by dull ashy-colored mountains.

The distance, by this pass, from Santa Isabel to San Felipe, is twelve miles, while the wagon road between these two points is twenty-five miles, or more, in length.

The geological formation exhibited along the eastern slope of the mountain range at this point shows a very sensible change, and in place of the usual forms of feldspathic or quartz granite we meet with a more prevalent character of micaceous granite, in which the scales of mica are frequently of large size, and very confusedly intermixed. With this also occur mica and talcose slates, traversed by quartz veins. At this point, then, we have an approach to the gold formation, and in the section of country thus limited, exist the fairest prospects of mineral discoveries.

The country thus characterized is, however, barren and desolate in the extreme; water is scarce, and pasturage of the poorest description. Thorny cacti and arid shrubbery usurp the soil, not only of the mountain clefts, but also of the open valleys. At this point, indeed, we may say, the desert proper commences; for it is here we have the first appearance of the desert plants *Larrea Mexicana* and *Fouquiera Splendens.*

On leaving the last rocky exposures to enter on the open desert plain, we pass some distance down the bed of Cariso creek; along the course of which are exposed the high bluffs of sand, marl, and clay, exhibiting a fine sectional view of the tertiary formation on which the desert plateau is based. At the point where the road leaves the bed of the creek, to mount to the desert table-land, some 150 feet above, fossil marine shells of *Ostrea* are found, and gypsum makes its appearance in extensive beds. The upper layer of the table-land shows a variable thickness, composed of water-worn pebbles, derived from the adjoining mountains. Near the mountain base, this plateau has a height of about 500 feet above the level of the Colorado river. The surface extends in a gentle slope towards the Colorado, or eastward, about the distance of twenty-five miles, where it reaches its lowest depression at the Lagoon or "New river" basin, which is in fact a part of the extended alluvial tracts belonging to the Colorado river.

The proof of this latter fact is seen in the barometric observations, showing a depression at this point, below the level of the Colorado river in high water, and also by tracing a direct connexion between the overflow of this latter stream and the appearance of water at New river. The numerous depressions found along the course of this alluvial tract have, moreover, all the character of the sedimentary soil of the Colorado bottoms, supporting, though more sparsely, the same character of vegetation, and showing, frequently, fluviatic shells, identical with those now found at lagoons and sloughs adjoining the river.

This "New river" tract also receives the drainage of a large scope of desert country, which is sometimes visited by heavy showers of rain. It retains this rain-water, and river overflows, for several months; when both these sources fail, it becomes a perfectly dry bed, or contracts into quaggy saline marshes.

When we stopped here, in the latter part of September, copious local rains had filled these lake reservoirs, which, with previous extensive river overflows, had enriched the soil and caused a rank growth of annual grama grass. This afforded a fine grazing camp for our animals for two months.

Directly south from our camp at this place, and about eight miles distant, lies a high mountain range, having a direction nearly east and west. To the western and most prominent point of this range the name of "Signal Mountain" was given. This range is made up of a form of sienitic rock, associated with recent lava. Its surface is bare, and presents a forbidding outline of dark weathered rock, variously marked by furrows, and shows an irregular crest, gradually sloping towards the east.

Our route hence to the Colorado river leaves this depressed alluvial tract to the south, and passes again over the hard, gravelly surface of the desert table-land till we come upon the regular wooded bottoms of the main river. These bottom-grounds are everywhere bounded by a distinct line of the desert table-land, which forms bluffs of greater or less height. The character of these bluffs is often obscured by drifting sand, which is constantly encroaching on the lower tracts.

Natural Section. East bank of the Colorado river below mouth of the Gila river. Length 600 yards.
A. Breccia of feldspathic granite. Height 50 feet above low-water mark.
B. Drift composed of fragments of the same, more rounded. The strata dipping on an angle of 35°.
CO. Old beds of Gila river below high-water mark.
D. Strata of sand, 40 feet high, with seams of harder character.
E. Layers of pebbles, 15 to 20 feet, corresponding to calcareous conglomerate forming the table-lands of the desert.
F. Line of high-water mark, 12 feet above G. Line of low-water mark.

This upper bottom-land is densely wooded with mezquite, which here finds its most congenial soil, and spreads its thorny branches on all sides, forming impenetrable thickets. To this higher level succeeds a lower surface of moist soil, supporting cotton-wood and willow, both of which extend to the immediate edges of the stream.

In passing up the river on its right bank to the junction of the Gila, we encounter a rocky ridge abutting directly on the river bank; thence rising inland into high rugged peaks, it forms the "Pilot Knob" range. The character of the rock, as exposed on the river bank, is *gneiss*, having a distinct laminated structure. This character gradually passes into a form of *sienite*, composing the principal mass of the adjoining mountain ridge.

The immediate junction of the Gila and Colorado rivers is marked by a formation different from any elsewhere noticed. It consists of rounded knolls, which rise from fifty to one hundred and fifty feet above the river level, and are strewn over with the erratic deposites belonging to the desert formation. Its internal structure is thus in a great measure concealed. In the cleft made by the passage of the Colorado, just below the junction, the central nucleus is brought to view, and exhibits a form of epidote rock, occurring as an irregular breccia, and showing evidence of internal disturbance below.

The Colorado river, below the junction, is barely five hundred feet across. The Gila, near its mouth, is one hundred and fifty feet wide. The depth of channel in each is very variable.

The alluvial delta lying north of the junction of these two rivers is considerably below high-water mark. It thus furnishes soil suitable for cultivation, and is occupied as such by the Yumas Indians. Some two miles above the junction, on the right bank of the Colorado, are marks of an old river bed, which, in the time of floods, is filled with an obstructed body of water, forming frequent sloughs and lagoons along its course. The

ground thus irrigated is occupied by another branch of the Yumas tribe for cultivation; the chief productions being maize, beans, pumpkins, and melons.

At the time of our arrival, in the month of October, it was the harvest season. The river overflows usually occur in the month of July. During the early part of the month of October the weather was oppressively sultry; the thermometer at mid-day frequently rising to 100° in the shade. The sky was remarkably clear, and the atmosphere extremely dry. During the month of November the air became sensibly cooler, especially at night; the thermometer sinking below 50° Fahrenheit. Heavy dews and fog at times, with cloudy weather and occasional showers, rendered the atmosphere more moist. Strong winds were frequent from the north, raising immense clouds of dust along the course of the river.

Natural Section. West bank of the Colorado river, opposite mouth of the Gila river. Height of B 70 feet.
A and B. Same as above.
C. Level of the Colorado bottom, 15 feet above water-mark.
D. Exposure of chlorite and talc, granulated, laminated, shooting up in the form of veins into the supercumbent mass.
E. Hills of the same character.
A being concealed by B.
F. High-water mark, 12 feet.

The water in the river channel varied but little during our stay, occasionally rising several inches, in consequence of heavy rains, and again sinking to the ordinary low-water level. Along the sides of the cañon, through which the river passes, below the junction of the Gila, there is plainly seen a line of high-water mark, showing an elevation of twelve feet or more above the usual level.

The character of the soil adjoining the river banks, derived from the sediment of river overflows and the light material borne by winds from the adjoining desert plateaux, causes along the bed of the stream the frequent formation of shifting sand-bars. These are perpetually changing with the variable river current. The process of deposition and removal is thus continually going on, rendering the river bed exceedingly variable and unequal in its depth and permanence.

The view of the adjoining country from any high elevation discloses a scene of unqualified barrenness and bleak sterility. The horizon is everywhere bounded by the bare outline of distant mountains, forming jagged and serrated ridges, or rising into various-shaped domes and chimney peaks. Intermediate, stretches the broad and desolate table-land, with its dead-brown aspect; while the more attractive river bottoms are seen clothed with a straggling growth of mezquite, or reflecting from turbid waters the overhanging willow and the lofty cotton-wood.

On the 1st of December, having completed our observations, we struck camp for our return to San Diego. The frequent rains of the previous month caused an abundance of water at convenient points along our road. In the bottoms of New river our teams were compelled to drag over muddy tracks. The opportune supply of de-

sert grama grass, which made this locality the recruiting station for our animals during our stay on the Colorado, was now entirely exhausted.

Leaving the wagon trains to follow out the ordinary road across the mountains, our advance party, under Lieutenant Coutts, left the wagon route at Cariso creek, to mount the height of the range, by a direct ascent, to the west. Following out at first a gradual slope by which we advanced towards a re-entering angle in the steep rocky range, we accomplished with ease nearly half the height of the mountain ridge. The rest of the ascent was literally climbing up steep rocky slopes, or winding along rude ravines; the height was finally gained, and was some 2,500 feet above the desert plain below. Thence our route led by a gentle slope towards the west, passing along beautifully shaded valleys, watered by clear flowing streams, and brought us to the coast near the initial point of boundary on the Pacific.

Major Emory's Report Resumed.

In 1846, I made a report of a rapid reconnoissance of the country here described by Dr. Parry. I preferred giving this description, taken from a different point of view, to reproducing my own sketch.

Dr. Parry accompanied me under the first organization as physician to the boundary commission, and also undertook the duties of zoologist and botanist. In the summer of 1854, when the second commission was organized under the new treaty with Mexico, the same position was offered him, but was declined. The appointment was then conferred on Dr. C. B. R. Kennerly.

In the list of officers of the expedition, (given on page 24,) the name of Dr. Kennerly is inadvertently omitted.

I cannot conclude the account of this part of the country, relating to the boundary, without some reference to a sad affair which occurred at the crossing of the Colorado, while the parties under my orders were engaged at that point, and which, at the time, excited much interest in the army and elsewhere. I refer to the death of the brave and accomplished Captain Thorn, of the army.

In the fall of 1849, Captain Thorn was detailed to escort, with his command, from the frontier of Missouri to California, the collector of the port of San Francisco. As may be supposed, the march was full of difficulties. When between Santa Fé and the Gila, the party was attacked by a force of Indians, which was gallantly repulsed by Captain Thorn and his command.

Arrived at the Colorado, most of the party fagged out and dispirited, Captain Thorn was obliged to use extraordinary exertion in crossing it. There was but one boat; and with that zeal and hardihood which characterized this officer in the discharge of all his duties, he stripped off his uniform, and took the personal direction of the boat. After having crossed and recrossed repeatedly, in ferrying over his command, and the party he escorted, the boat sank. The captain, although a good swimmer, became entangled with a Mexican who was in the boat, probably in the chivalrous attempt to save him, went down, and was swept away by the current.

I was at the time in my camp, distant one hundred and fifty miles, where a soldier came in and reported the circumstance, stating that the body had not been found when he left. I immediately despatched an Indian runner to Lieutenant Coutts, who commanded a

company of dragoons engaged in escorting a surveying party of the boundary commission, to turn out his whole force, and search the river to its mouth for the recovery of the captain's body. He succeeded in obtaining it some miles below the crossing, where it was found by the Indians, and had it carefully placed in a coffiin, with the intention of bringing it to my camp; but in passing through San Diego, the officers of the 2d infantry, to which regiment Captain Thorn then belonged, who were stationed there, claimed the body, and took possession of it.

Previous to setting out on the expedition to California, I applied to have Captain Thorn assigned to duty with my command. This and other considerations made me desirous of recovering his body and sending it to his friends; but I could interpose no claim over that of the officers of his own regiment. I close this brief account of the circumstances attending the loss of a valued friend and brave brother officer by giving the letter of Lieutenant Coutts, which accompanied his remains:

CAMP CALHOUN, CALIFORNIA, *November* 11, 1849.

MAJOR: I have succeeded in making a box that will probably carry the remains of the lamented Captain Thorn to San Diego. In the absence of all material and conveniences for effecting this desired object properly, my carpenters have done better than I expected of them. I send the whole under the charge of Mr. Wiatt, a citizen, with one of my teamsters and a dragoon. They will procure a fresh team at Salvation camp, and should reach San Diego by the 23d instant. It will not, of course, be necessary for the teamster and dragoon to return.

* * * * * * * * * * *

I have the honor to be, your obedient servant,

CAVE J. COUTTS,

Lieutenant 1st Dragoons, commanding Escort.

Maj. W. H. EMORY,

Commanding Escort to Boundary Commission, Camp Riley, California.

Tabulated distances of routes along and in the neighborhood of the boundary line between the United States and Mexico, from the Pacific ocean to the Gulf of Mexico, measured by viameters, by Lieut. N. Michler, Lieut. Parke, and Assistant Chandler.

From—	To—	Distance.	Distance from starting point.	Total distance.
		Miles.	*Miles.*	*Miles.*
Newtown or New San Diego	Old San Diego	2	2	
Old San Diego	Fisher's Rancho	8.95	10.95	
Fisher's Rancho	Panasquitas	8.02	18.97	
Panasquitas	San Pasqual	18.87	37.84	
San Pasqual	Laguna	12	49.84	
Laguna	Santa Isabel	11.40	61.24	
Santa Isabel	Warner's Rancho	10.33	71.57	
Warner's Rancho	San Felipe	15.88	87.45	
San Felipe	Vallecito	17.85	105.30	
Vallecito	Carrizo creek	16.60	121.90	
Carrizo creek	Big Laguna	26.41	148.31	
Big Laguna	New River	5.83	154.14	
New river	Little Laguna	4.50	158.64	
Little Laguna	Alamo Mocho	16.44	175.08	
Alamo Mocho	Cook's Well	21.94	197.02	
Cook's Well	Fort Yuma	20	217.02	
Newtown	Fort Yuma			217.02

TABLE—Continued.

From—	To—	Distance.	Distance from starting point.	Total distance.
		Miles.	*Miles.*	*Miles.*
Fort Yuma	1st Laguna	7.7		
1st Laguna	2d Laguna	1.3	9	
2d Laguna	3d Laguna	10.8	19.8	
3d Laguna	4th Laguna, camp near New Initial Point.	1.5	21.3	
Fort Yuma	Rowlett's Rancho	2.63	2.63	
Rowlett's Rancho	Camp No. 4	4.86	7.49	
Camp No. 4	Camp No. 5	20.88	28.37	
Camp No. 5	Camp No. 6	14.79	43.16	
Camp No. 6	Los Metates	2	45.16	
Los Metates	Camp No. 7	14.84	60	
Camp No. 7	Camp No. 8	11.50	71.50	
Camp No. 8	Lomas Negras, Camp No. 9	16.72	88.22	
Lomas Negras	Camp No. 10	13	101.22	
Camp No. 10	Camp No. 11	9.50	110.72	
Camp No. 11	Camp No. 12	10.50	121.22	
Camp No. 12	Camp No. 13	10	131.22	
Camp No. 13	Camp No. 14, at Tezotal	10.50	141.72	
Camp No. 14, at Tezotal	Camp No. 15, Maricopa Wells	40	181.72	
Camp No. 15, Maricopa Wells	Camp No. 16, Pimo village of Cola Azul.	15	196.72	
Camp No. 16, Pimo village of Cola Azul.	Camp No. 17, last point of the Gila.	14	210.72	
Camp No. 17, last point of Gila	Picacho on the Jornada	35	245.72	
Pichaco on the Jornada	Tucson	35	280.72	
Fort Yuma	Tucson			280.72
Tucson	San Xavier	9		
San Xavier	Agua de la Canoa	25	34	
Agua de la Canoa	Ford of Santa Cruz river	12	46	
Ford of Santa Cruz river	Tubac	2.50	48.50	
Tucson	Tubac			48.50
San Xavier	Cienega de los Pimos	24		
Cienega de los Pimos	San Pedro river	23.52	47.52	
San Pedro river	Quercus Cañon	6	53.52	
Quercus Cañon	Plaza de los Pimos, Croton Spring	30.76	84.28	
Plaza de los Pimos	Puerto de Dado	30	114.28	
Puerto del Dado	Cienega del Sauz	25.30	139.58	
Cienega del Sauz	Ojo de la Vaca	54.05	193.63	
Ojo de la Vaca	Rio Mimbres	17	210.63	
Rio Mimbres	Cook's Spring	17.60	228.23	
Cook's Spring	Mesilla	53.11	281.34	
Mesilla	Fort Fillmore	2.50	283.84	
Fort Fillmore	Franklin	40	323.84	
[a]San Xavier	Franklin			323.84
Tubac	Ojo del Agua de Sopori	10.25	10.25	
Ojo del Agua de Sopori	Aribaca	18.25	28.50	
Aribaca	Ojos de las Boquillas	9.10	37.60	
Ojos de las Boquillas	Laguna	25.08	62.68	
Laguna	Coyotes	9.70	72.38	
Ojos de los Coyotes	Charcos de Alvarez	16.49	88.87	
Charcos de Alvarez	Rancho de Cobota	25.73	114.60	
Rancho de Cobota	Puerto de la Nariz	44.85	159.45	
Puerto de la Nariz	Sonoyta	24.55	184	

[a] The distances from San Xavier to Franklin were furnished by Lieut. J. G. Parke, Top. Engineers, U. S. A.

TABLE—Continued.

From—	To—	Distance.	Distance from starting point.	Total distance.
		Miles.	*Miles.*	*Miles.*
Tubac	Mission of Tomocacari	2. 61	2. 61	
Mission of Tomocacari	Rancho de las Calabasas	10. 37	12. 98	
Tubac	Calabasas			12. 98
Rancho de las Calabasas	Observatory at Los Nogales	8	8	
Observatory at Los Nogales	Monument on Line	3. 97	11. 97	
Monument on Line	Agua Zarca	11. 39	23. 36	
Agua Zarca	Casita	14. 79	38. 15	
Casita	Los Alisos	3. 73	41. 88	
Los Alisos	Imuris	11. 37	53. 25	
Rancho de las Calabasas	Rancho de San Lazaro	35	35	
Rancho de San Lazaro	Santa Cruz	7. 18	42. 18	
Rancho de las Calabasas	Santa Cruz			42. 18
Newtown	Fort Yuma	217. 02		
Fort Yuma	Tucson	280. 72	497. 74	
Tucson	Tubac	48. 50	546 24	
Tubac	Rancho de las Calabasas	12. 98	559. 22	
Rancho de las Calabasas	Santa Cruz	42. 18	601. 40	
Newtown	Santa Cruz, via Ft. Yuma & Tucson			601. 40
Fort Yuma	Camp near New Initial Point on Rio Colorado.		21. 30	
Tubac	Sonoyta		184	
Rancho de las Calabasas	Imuris		53. 25	
Fort Yuma	Point of departure from Gila	2. 63	2. 63	
Point of departure from Gila	Las Cuevitas	26. 45	29. 08	
Las Cuevitas	Las Tinajas Altas	16. 49	45. 57	
Las Tinajas Altas	El Corral	15. 33	60. 90	
El Corral	El Tule	1. 15	62. 05	
El Tule	La Salada	44. 89	106. 94	
La Salada	Agua Dulce	2. 89	109. 83	
Agua Dulce	Quitobaquita	6. 54	116. 37	
Quitobaquita	Santo Domingo	5. 70	122. 07	
Santo Domingo	Rancho de Sonoyta	7. 73	129. 80	
Rancho de Sonoyta*	Pozo del Macias	47. 15	176. 95	
Pozo del Macias	Rancho del Soñi	8. 70	185. 65	
Rancho del Soñi	Las Caborqueñas	22. 69	208. 34	
Las Caborqueñas	Rancho del Bamori	15. 83	224. 17	
Rancho del Bamori	Las Tinajitas	6. 73	230. 90	
Las Tinajitas	Altar	4. 65	235. 55	
Fort Yuma	Altar			235. 55
Altar	Charco de San Raphael	8	8	
Charco de San Raphael	Rancho del Ocuca	18. 4	26. 4	
Rancho del Ocuca	Pueblo de Santa Anna	21. 38	47. 78	
Pueblo de Santa Anna	Pueblo de Santa Marta	2. 84	50. 62	
Pueblo de Santa Marta	Pueblo de San Lorenzo	4. 68	55. 30	
Pueblo de San Lorenzo	Pueblo de la Magdalena	4. 76	60. 06	
Pueblo de la Magdalena	San Ignacio	4. 78	64. 84	
San Ignacio	Imuris	6. 62	71. 46	
Altar	Imuris			71. 46

* The distances from Fort Yuma to Sonoyta were furnished by Don Francisco Jimenez, Mexican commission.

TABLE—Continued.

From—	To—	Distance.	Distance from starting point.	Total distance.
		Miles.	*Miles.*	*Miles.*
Altar	Charco San Raphael	8	8	
Charco San Raphael	Rancho de las Boquillas	16	24	
Rancho de las Boquillas	Laguna near Lomita	3. 10	27. 10	
Laguna near Lomita	Rancho de los Alamitos	3. 16	30. 26	
Rancho de las Alamitos	Ford of San Ignacio	2. 67	32. 93	
Ford of San Ignacio	Rancho de Arequabo	2. 38	35. 31	
Rancho de Arequabo	Rancho Espinosa	12. 80	48. 11	
Rancho Espinosa	Pueblo Santa Anna	13. 28	61. 39	
Imuris	Rancho de Babasaqui	5	5	
Rancho de Babasaqui	Cocospera	15. 81	20. 81	
Cocospera	San Lazaro	17. 28	38. 09	
San Lazaro	Santa Cruz	7. 18	45. 27	
Imuris	Santa Cruz			45. 27
Newtown	Fort Yuma	217. 02		
Fort Yuma	Altar	235. 55	452. 57	
Altar	Imuris	71. 46	524. 03	
Imuris	Santa Cruz	45. 27	569. 30	
Newtown	Santa Cruz, via Ft. Yuma and Altar			569. 30
Santa Cruz	1st tributary of San Pedro	13. 50		
1st tributary San Pedro	2d do do (des'ted rancho)	16	29. 50	
2d do do (deserted rancho)	3d do do	1. 97	31. 47	
3d do do	4th do do	0. 50	31. 97	
4th do do	5th do do (Sauz)	3	34. 97	
5th do do (Sauz)	6th do do	9. 81	44. 78	
6th do do	Ash creek	22. 32	67. 10	
Ash creek	San Bernardino	30. 16	97. 26	
San Bernardino	Entrance of Guadalupe cañon	9. 27	106. 53	
Entrance of Guadalupe cañon	Camp in the cañon	12. 73	119. 26	
Camp in the cañon	San Luis Springs	11. 70	130. 96	
San Luis Springs	San Francisco	16. 10	147. 06	
San Francisco	Pelatado	27. 13	174. 19	
Pelatado	Janos	10. 50	184. 69	
Janos	Corralitas	20. 26	204. 95	
Corralitas	Mines of San Pedro	19	223. 95	
Mines of San Pedro	Santa Maria	27. 18	251. 13	
Santa Maria	Salado	27	278. 13	
Salado	Samalurca	36. 31	314. 44	
Samalurca	El Paso	25. 02	339. 46	
Santa Cruz	El Paso			339. 46
Janos	Las Lagunitas	8. 7		
Las Lagunitas	Palos Blancos	13. 8	22. 5	
Palos Blancos	Espia	14. 1	36. 6	
Espia	Desechado	18. 8	55. 4	
Desechado	Carrizalillo	19. 3	74. 7	
Carrizalillo	Mountain Camp	22. 6	97. 3	
Mountain Camp	Ojo de Vaca	20	117. 3	
Ojo de Vaca	Rio Mimbres	18. 7	136	
Rio Mimbres	Cook's Spring	19. 7	155. 7	
Cook's Spring	Cañon Camp	28. 1	183. 8	
Cañon Camp	Mesilla Ford	30. 5	214. 3	
Mesilla Ford	Alamos	21	235. 3	
Alamos	Franklin	21. 5	256. 8	
Janos*	Franklin, (opposite El Paso)			256. 8

* The distances from Janos to Franklin were furnished by Mr. Chandler, assistant United States boundary commission.

TABLE—Continued.

From—	To—	Distance.	Distance from starting point.	Total distance.
		Miles.	*Miles.*	*Miles.*
Franklin, (opposite El Paso)	Fort Bliss	2		
Fort Bliss	Isleta	12.14	14.14	
Isleta	Socorro	3.10	17.24	
Socorro	San Elceario	5.45	22.69	
San Elceario	Last camp on Rio Grande	59.80	82.49	
Last camp on Rio Grande	Eagle Springs	31.42	113.91	
Eagle Springs	Van Horn's Wells	19.74	133.65	
Van Horn's Wells	Dead Man's Hole	32.83	166.48	
Dead Man's Hole	Barrel Spring	13.58	180.06	
Barrel Spring	Fort Davis	18.42	198.48	
Fort Davis	Varela Springs	28	226.48	
Varela Springs	Leon Springs	33.86	260.34	
Leon Springs	Comanche Springs	8.88	269.22	
Comanche Springs	Ojos Escondidos	19.40	288.62	
Ojos Escondidos	Arroyo Escondido	8.58	297.20	
Arroyo Escondido	First camp on Pecos	16.26	313.46	
First camp on Pecos	Ferry of Pecos	38.26	351.72	
Ferry of Pecos	Live Oak creek	7.29	359.01	
Live Oak creek	Howard's Springs	30.44	389.45	
Howard's Springs	First camp on San Pedro	44	433.45	
First camp on San Pedro	2d crossing of San Pedro	19.50	452.95	
2d crossing of San Pedro	Palos Blancos	18.39	471.34	
Palos Blancos	Painted Caves	15.73	487.07	
Painted Caves	1st crossing San Pedro	2.54	489.61	
1st Crossing of San Pedro	San Felipe	10.22	499.83	
San Felipe	Arroyo Pedro	8.80	508.63	
Arroyo Pedro	Zoquete creek	3.81	512.44	
Zoquete creek	Piedra Pinta	8.86	521.30	
Piedra Pinta	Las Moras, (Fort Clark)	7	528.30	
Las Moras (Fort Clark)	Elm creek	7.13	535.43	
Elm creek	Turkey creek	15.23	550.66	
Turkey creek	Nueces	10.27	560.93	
Nueces	Head of Leona	9.04	569.97	
Head of Leona	Rio Frio	6.08	576.05	
Rio Frio	Comanche creek	8.46	584.51	
Comanche creek	Sabinal	5	589.51	
Sabinal	Rancheros creek	3.94	593.45	
Rancheros creek	Rio Seco, (Dhanis)	8.38	601.83	
Rio Seco, (Dhanis)	Quihi	15.28	617.11	
Quihi	Castroville	10	627.11	
Castroville	Leon	18	645.11	
Leon	San Antonio	6.53	651.64	
El Paso	San Antonio			651.64
San Antonio	Port Lavaca			128.50
San Antonio	Indianola			138

TABLE—Continued.

SUMMARY.

From—	To—	Distance.	Distance from starting point.	Total distance.
		Miles.	*Miles.*	*Miles.*
New San Diego, via Fort Yuma and Altar.	Santa Cruz	569. 30		
Santa Cruz	El Paso	339. 46	908. 76	
El Paso	San Antonio	651. 64	1, 560. 40	
San Antonio	Indianola	138. 00	1, 698. 40	
New San Diego	Indianola			1, 698. 40
New San Diego, via Fort Yuma and Tucson.	Santa Cruz	601. 40		
Santa Cruz	El Paso	339. 46	940. 86	
El Paso	San Antonio	651. 64	1, 592. 50	
San Antonio	Indianola	138	1, 730. 50	
New San Diego	Indianola			1, 730. 50
New San Diego	Fort Yuma	217. 02		
Fort Yuma	San Xavier	289. 72	506. 74	
San Xavier	Franklin	323. 84	830. 58	
Franklin	San Antonio	651. 64	1, 482. 22	
San Antonio	Indianola	138. 00	1. 620. 22	
New San Diego	Indianola			1, 620 22

CHAPTER VIII.

ASTRONOMICAL AND GEODETIC WORK.

PREFACE.

1. Classes of observations.
2. Longitude.
3. Latitude.
4. Geodetic measurement of azimuth lines.
5. Tracing of parallels.
6. Computations.

A.—Determination of Boundary Line from the Initial Point on the Pacific Ocean to junction of the Gila and Colorado.

1. Longitude of Camp Riley, near Initial Point, on the Pacific.
2. Longitude of junction of Gila and Colorado.
3. Latitude of Camp Riley,
4. Latitude of junction of Gila and Colorado.
5. Triangulation, transferring the determination at Camp Riley to Initial Point, on the Pacific.
6. Azimuth of straight line from Initial Point, on Pacific, to junction of Gila and Colorado.

B.—Determination of Boundary Line from Rio Colorado to intersection of 111th meridian of longitude west of Greenwich and parallel 31° 20′ N.

1. Azimuth line—astronomical positions.
2. Triangulation for determining longitude of Initial Point on the Colorado.
3. Tabulated results of latitude.
4. Distances between monuments.

C.—Determinations of the Boundary Line along parallels 31° 47′ and 31° 20′ N.

1. Latitude and longitude of Los Nogales, near intersection of 111th meridian and 31° 20′.
2. Latitude near the head of Santa Cruz river.
3. Latitude of San Bernardino.
4. Latitude of San Luis springs.
5. Latitude of Agua del Perro.
6. Latitude of Espia.
7. Latitude and longitude of Carrizalillo.
8. Latitude of Initial Point on Rio Grande.
9. Azimuths for laying off the Prime Vertical at above stations.
10. Elements for marking parallels of latitude 31° 20′ and 31° 47′.

D.—Boundary Line formed by the Rio Grande.

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   - *a.* Frontera.
   - *a′.* San Elceario.
   - *b.* El Paso del Norte.
   - *c.* Mouth of cañon where road from San Antonio to El Paso strikes the Rio Grande.
   - *d.* Presidio del Norte.
   - *e.* Fort Duncan.
   - *f.* Ringgold barracks.
   - *g.* Mouth of the Rio Bravo del Norte.
2. Of Latitudes:
   - *a.* Frontera.
   - *b.* San Elceario.
   - *c.* Mouth of cañon where road from San Antonio to El Paso strikes the Rio Grande.
   - *d.* Presidio del Norte.
   - *e.* Fort Duncan.
   - *f.* Ringgold barracks.
   - *g.* Mouth of Rio Grande.

E.—Table of Latitudes and Longitudes of points on and near the Boundary Line between the United States and Mexico.

PREFACE.

I. Classes of Observations.

The observations for the determination of the latitude and longitude were of two classes—the first being those which were made at primary stations with the largest instruments that could be conveniently transported by land ; the second, those made at places of less importance, determined by reflecting instruments, and by the transmission of chronometers from the nearest primary stations, or by flashes of gunpowder, observed simultaneously. Eighteen stations of the first class were established across the continent at the following places, named in their order, from west to east:

1. Camp Riley, near initial point, on the Pacific coast ; 2. Junction of the Gila and Colorado ; 3. On the Colorado, where the line leaves that river ; 4. Quitobaquita ; 5. Los Nogales, near 111th meridian of longitude ; 6. San Bernardino, near parallel 31° 20′ ; 7. San Luis springs, near parallel 31° 20′ ; 8. Agua del Perro ; 9. Espia ; 10. Carrizalillo, near parallel 31° 47′ ; 11. Frontera ; 12. San Elceario ; 13. Initial point of boundary on parallel 31° 47′ ; 14. Cañon where the San Antonio road leaves the Rio Bravo ; 15. Presidio del Norte ; 16. Eagle Pass, (Fort Duncan ;) 17. Ringgold Barracks ; 18. Mouth of Rio Bravo.

I do not enumerate the very many points of lesser importance determined by the sextant and chronometer, as no special notice is required of the means used in their determination. It may be as well to state, however, that in all cases where observations were made for latitude with reflecting instruments, stars were taken, both north and south, and at altitudes as nearly equal as could be obtained ; and when local time was obtained by these instruments, stars were taken both east and west, of nearly equal altitudes, and as near the prime vertical as they could be found. In this way we attempted to avoid the errors arising from refraction and from the eccentricity of the instrument.

In some cases, where I had direct comparisons with results obtained by the large instrument, I ascertained that the latitude of a place determined by the Gambey sextant in the proper hands, in a single night, might be relied upon to within 3″ or 5″; and if the observation was repeated for two nights, the result might be relied upon to be within 2″ of the true position.

II. Longitude.

The longitudes of 1, 2, 4, 5, 10, 11, 12, 15, 16, 17, 18, were obtained by observations on the transit of the moon and moon culminating stars, with a telescope of forty-six inches' focal length, by Troughton & Simms, of London, and with a smaller one of thirty-six inches' focal length. Occultations were observed, whenever practicable; but, owing to the impossibility of obtaining corresponding observations, they proved of little value; indeed, but few were observable. Occultations are no doubt of the greatest value where corresponding observations at some established point are observed ; but for the general purposes of a survey, conducted in distant regions, they are not a sure reliance. They occur too seldom ; and to see the instant of immersion and emersion of a star requires great steadiness in the telescope, which in the field can be rarely obtained, owing to the difficulty of protecting the telescope from the wind, and of getting a firm support.

After giving what I considered a fair trial in the field to all the methods now known, it was concluded to place the chief reliance on the transit of the moon. If, however, it happens to me to be again in charge of extensive operations of the kind, I shall make some effort to improve the instruments for the observation of lunar distances. I am satisfied it is in that direction itinerant observers must look for improved methods and facilities in obtaining longitude.

When the reflecting instruments are made so as to be placed more firmly and quickly in any given plane, and the methods of computing lunar distances are improved and simplified, it will be in the power of the observer any clear night, when the moon is above the horizon, to multiply his observations so as to obtain close results. The instruments in present use have not sufficient power to observe near contacts of the moon and stars; and in the attempts which have been made to increase the power of the telescope, the instrument becomes insupportable by the hand for repeated or nice observations.

In all cases where it was not necessary to declare the result on the spot, as at those stations at the extremities of azimuth lines, and at stations such as the 111th meridian of longitude, which formed turning-points in the boundary, the longitude was deduced from corresponding observations made at Greenwich. In some few cases we obtained corresponding observations at the American observatories; but the observations were not sufficiently continuous at any of these last-named observatories to enable us to rely upon them. And I have here to repeat (what I have heretofore expressed to the American Association for the Advancement of Science) my obligations to Astronomer Royal Airy for the trouble he has taken to furnish the corresponding observations in MSS. before they were published at Greenwich.

In the personal account, mention is made of the agreement made with the Mexican commissioner to declare the 111th meridian, from computations based on the data afforded by the Greenwich Ephemeris,* before receiving the corresponding observations. This arrangement was a necessity arising from our isolated position near the centre of the continent, cut off from all intercourse except by expresses protected by armed escorts. To have awaited the reception of the corresponding observations would have detained us fully eighteen months, at great expense—a result not contemplated by either the United States or Mexican governments, and not contemplated by the treaty, which provided against any possible errors in the location of the line by declaring, "that line shall alone be established upon which the commissioners may fix; their consent in this particular being considered decisive and an integral part of this treaty, without necessity of ulterior ratification or approval, and without room for interpretation of any kind by either of the parties contracting."

The observations at 1, 11, 13, 14, 15, 17, were made by myself in person; those at 2, by Lieutenant Whipple; at 4, by Señor Jimenez, first engineer Mexican boundary commission; at 5, 10, and 16, by Assistant John H. Clark; at 18, by Assistants Gardner and Clark; and at 12, by Lieutenant W. F. Smith. At most of the stations the observations were carried through at least three lunations; but, it will be seen, the result was not changed materially after the first lunation.

The longitude of the point where the boundary leaves the Rio Bravo was transferred from Frontera by triangulation; and the longitude of El Paso and of No. 14 (the cañon) were respectively transferred from Frontera and San Elceario by flashes of gunpowder simultaneously

* When this agreement was made, no copy of the American Ephemeris had been received, nor was I aware it had been published.

observed. It was my desire to extend this beautiful and accurate mode of obtaining differences of longitude to many other stations; but in a country without settlements, and traversed by bands of savages who kill at sight, it was impossible to do so, as every party that went out had to be escorted by ten or fifteen armed men.

Where neither of the above means could be resorted to, longitude was obtained by transmission of chronometers from some established point. This method, so successful at sea, where the motion is uniform and smooth, has objections on land, principally the impossibility of moving chronometers without deranging the rate. Every method of transporting them was tried—on carriages, on foot, and on horseback; and an ordinary spring-carriage was found to be the best. No test can be applied to check an error in determining longitude by the transmission of chronometers; for even with three chronometers it is possible for all to be affected in the same way, though of course not in the same degree—that is to say, all may run, while travelling, too fast or too slow; and when you halt, may resume their former rates.

The observations at the two stations 11 and 12—Frontera and San Elceario—being about the centre of the continent, and in a geographical point of view more important than any others, were combined to arrive at the results given.

The longitude of Frontera from moon culminations, extending through four lunations, computed from the predicted place of the moon and moon culminating stars, given in the Greenwich Ephemeris for 1851–'52............ $= 7^h\ 05^m\ 55^s.3$

The same, after applying the correction due for corresponding observations made at Greenwich and furnished in MSS. from the Observatory at that place, is—

For the 1st lunation,	December and January, 1851–'52......	7 06 11.38	
2d "	January and February, 1852...........	13.34	
3d "	February and March, "	14.73	
4th "	March and April, "	12.48	
Mean..			7 06 12.98
Difference due to correction........................			+ 17.68

The longitude of San Elceario deduced from observations on forty moon culminations, extending through three lunations, computed from the predicted place of the moon and moon culminating stars, given in the Greenwich Ephemeris for 1852 .... $7^h\ 04^m\ 46^s.55$

The same, after applying the correction due for corresponding observations made at Greenwich, is—

For the 1st lunation,	January and February, 1852...........	7 05 02.52	
2d "	February and March, "	04.31	
3d "	April, "	03.44	
Mean..		7 05 03.42	

By combining these observations with corresponding ones at Cambridge, Mass., we get.. 7 05 04.3

Difference due to correction........................ + 17.75

The coincidence between these differences is satisfactory. The computations were made by independent computers: the first, by Assistant J. H. Clark; the second, by Assistant J. O'Donoghue. The observations for the first were made by myself; those at San Elceario by Lieutenant W. F. Smith.

To give greater effect to the results, and to establish beyond the probability of future change the longitude of Frontera—which is about the longitude of the middle of the continent, and is a primary station on the survey of the boundary—an attempt was made to connect the observatory of San Elceario with that of Frontera by flashes of gunpowder, and the following is the result. It should be observed that the Frontera here mentioned is not the Frontera of the old maps of North America. Frontera signifies a frontier town, but in this instance is the name given by its proprietor to a newly-constructed hut, built immediately on the ratification of the treaty of Guadalupe Hidalgo, at a point some eight miles above El Paso, where it was supposed the boundary under that treaty would leave the Rio Bravo. The difference of longitude between Frontera and San Elceario, observed by flashes on the nights of the 14th, 18th, 19th February, and 14th March, 1852, was found to be as follows:

Date.	No. of observat'ns each night.	Diff. of long., El Paso, east of Frontera.	No. of observat'ns each night.	Diff. of long., San Elceario, east of Frontera.
1852.		s.		m. s.
February 14	14	16.03	13	1 7.16
18	15	16.06	15	1 7.54
19	12	15.84	15	1 7.36
March 14	12	15.84	14	1 7.15
	Mean of 53 observations =	15.94	Mean of 57 observations =	1 7.30

The difference of longitude by observations on the moon and moon culminating stars is 1^m $08^s.58$, which agrees with that determined by flashes within $1^s.3$. Now, assuming the difference determined by flashes as correct, and giving equal weight to the observations at each station, the longitude of Frontera will be diminished by $0^s.65$, and that of San Elceario will be increased by the same quantity; so that the final result will be:

Frontera, west of Greenwich	7^h 06^m $12^s.33$
San Elceario " "	7 05 $04^s.95$

The longitude of the observatory at El Paso erected by the Mexican commission, two hundred feet south and five hundred feet west of the Cathedral tower, was determined by flashes observed simultaneously by Señor Salazar and myself on the nights stated in the preceding part of this article, to be $15^s.94$ east of Frontera; hence the longitude of El Paso, 7^h 05^m $56^s.39$.

A discussion of the longitudes of the Presidio del Norte and of Eagle Pass, on the Rio Grande, shows a difference between the longitude obtained by using the Greenwich Ephemeris and that obtained by using the corresponding observations at Greenwich, to be in the first case $+ 19^s$, and in the second $+ 17^s.1$. Comparing these with the same quantities obtained at Frontera and San Elceario, made in the same year, it will be seen that there is a coincidence, showing that in this case the error in the predicted place of the moon is nearly uniform for the same year.

The difference between the longitudes obtained in 1849, those computed from data in the

Greenwich Ephemeris, and those obtained by corresponding observations at Greenwich, was pretty generally + 12^s. This confirms the importance of a thorough revision of the lunar tables. The uniformity observable in these results shows, I hope, the probability of detecting the error, and eliminating or reducing it.

I have deposited in the Department of the Interior two volumes containing, in tabulated form, all the individual observations and computations upon which the results obtained on the boundary for longitude are founded. I give a leaf from these volumes, to show the manner in which the observations were made and computed. It has been suggested to me to present them for publication; but as each would make a volume nearly the size of the Greenwich Observations, I have contented myself, in this publication, with presenting in tabulated form the separate results, and in two cases—at the initial point on the Pacific, and at the mouth of the Rio Bravo—I have extended the table so as to show in detail the manner in which all the observations and computations have been tabulated. It has been found convenient, also, to incorporate with these tables the computations by which the azimuth lines forming portions of the boundary were determined.

III. Latitudes.

The latitudes of all the primary astronomical stations, except four, were determined either by myself or by Assistant J. H. Clark, with the zenith telescope. Two of the four excepted were determined by Lieutenant Whipple, the other two by Lieutenant Michler. I have placed in the Department of the Interior four volumes containing the individual observations and the computations for the latitude of the primary stations. In regard to the publication of these volumes, the same remarks that were made above in reference to the longitudes apply here. I give a leaf from them also, to show the mode of tabulating and computing the observations.

The tables attached hereto present a recapitulation of all the results for the latitudes of the primary stations, including the station determined by Lieutenant Michler, by circum-meridian altitudes of northern and southern stars observed with a sextant, and those determined by Lieutenant Whipple, by observing the transit of stars over the prime vertical.

The method habitually used on the boundary for obtaining latitude—that by the measurement of the difference of zenith distance of stars near the zenith, and nearly equidistant, north and south—is now so generally used and approved as to make no particular notice of it necessary. It was first adopted by Captain Talcott, in 1835, on the survey of the Ohio boundary. It was resumed by myself on the northeastern boundary; and some of my results coming under the eye of Professor Bache, he concluded to try it on the Coast Survey, and called on me for any suggestion I might have to make in reference to the form. I made the suggestions which resulted in the form in which the instrument is now made by Troughton & Simms, of London, and is that which I used on the present boundary survey.

Attached to the table combining the results of the observations at each station is a table showing the correction applied to the places of stars, derived either from actual observations of stars at the Washington Observatory, and politely furnished for the use of the boundary survey, or from the Twelve-year Catalogue of the Greenwich Observatory.

A comparison of the results obtained by the zenith telescope, with the errors developed in the declination of stars of the British Association catalogue, will show the rapid march field operations have made, in point of accuracy, upon the observations at the fixed observatories.

While the results confirm the excellence of the zenith telescope for field operations, they indicate the necessity of a more extended and accurate catalogue of stars.

IV. Geodetic Measurement.

The azimuth lines were ascertained by observations on the elongation of Polaris, and the measurement on the face of the earth was made with several different instruments. Those in California with a transit by Ertel & Son, Munich; with a horizontal limb of fifteen inches diameter, graduated to read to 10″. The instruments used in tracing the parallel of latitude were a ten-inch azimuth circle, by Gambey, of Paris; two by Bruner; and one by Draper, of Philadelphia. Some of the barometers used were by Bunten, of Paris; but they were chiefly made by James Green, of New York. They, together with the thermometers, were compared with the standard at the Smithsonian Institution, both before and after being used.

In tracing the parallels of latitude 31° 47′ and 31° 20′, and also in prolonging the azimuth line across California, and from the Rio Colorado to the 111th meridian of longitude, it frequently happened that it was convenient to take the meridians determined by the transit instrument, but most usually they were taken from the measurements of the elongation of Polaris.

V. Tracing the Parallels.

The parallels were determined by tracing a tangent to the prime vertical at any given point, and measuring the ordinates to the parallel. The use of the tangent instead of the chord was preferred, because the measurement of the ordinates, confided to a variety of assistants, presented always an increasing series, and was less liable to lead to confusion; a precaution very necessary in a country where water is scarce, and where parties operating have constantly to be on the alert against attacks of Indians. A general sketch of the stations established in latitude to trace these parallels is stated in the agreement with the Mexican commissioner, which will be found under the head of Personal Account, in Chapter II, and it is therefore unnecessary to repeat it here.

Great as were the embarrassments in other respects, the absence of trees gave us great facility in tracing these lines, and enabled us easily to correct errors resulting from producing long lines.

In the determinations of latitude along the same parallel, it will be seen we used the same instrument, and, as far as practicable, the same sets of stars; so we were quite certain of getting correct differences of latitude between two stations. In no case was it attempted to produce the same tangent in one direction more than thirty miles, and it was then always compared with the tangent from the new latitude station. The parallel of latitude thus deduced by separate and independent operations seldom differed more than a few feet; and in no case was the discrepancy sufficiently great to make it necessary to retrace our steps. The tangents, being few in number, were generally laid off by myself, and prolonged by the principal assistant surveyors, who were furnished with tables of ordinates and angles, which will be found in the appendix, that enabled us at once, and by simple measurements, to establish points in the parallels forming the boundary.

VI. Computations.

The computations were all made in the field originally, and subsequently revised in the office.

The observations made in California were computed in the field by myself, Lieutenant Whipple, and James Nooney. They were all subsequently revised by Professor Hubbard, and the new element of corresponding observations introduced into the computations for longitude. The observations on the Rio Bravo were computed in the field by myself and Assistants J. H. Clark and J. O'Donoghue, and revised in the office by Captain George Thom, corps of topographical engineers, and Assistant C. N. Thom.

The observations on the parallels 31° 47′ and 31° 20′ were all computed in the field by Principal Assistant J. H. Clark, Lieutenant Turnbull, corps of topographical engineers, and Assistant Hugh Campbell, and revised in the office by the same.

The observations at the point where the line strikes the Rio Colorado were made and computed by Lieutenant Michler and Assistant J. O'Donoghue.

A.

Determination of the line forming the boundary between the United States and the republic of Mexico, from the Initial Point on the Pacific ocean to the point where the "Gila river empties into the Colorado." By Brevet Major William H. Emory, Chief Astronomer.

This portion of the boundary consists of a straight line from a point on the Pacific ocean, one marine league south of the port of San Diego, to the junction of the Gila and Colorado. The most obvious way of determining the direction of this line was to connect the two points by triangulation, and in this way ascertain their relative positions on the face of the earth, and compute the azimuth of the line joining them. But the character of the intervening country made it impossible to pursue this mode of operating when the time and means at the disposal of the joint commission were considered. Triangulation is the surest, but it is the slowest and most expensive method of surveying, even in old-settled countries, where the stations to be selected are easily accessible in wagons. In the country under consideration obstacles presented themselves almost insurmountable. The whole distance, about 148 miles, may be divided into two nearly equal parts, differing in character, but both equally unfavorable to geodetic operations. The first, rising in steppes from the sea, and covered with spinose vegetation, attains, in abrupt ascents, the height of five or six thousand feet in the short space of thirty miles. From this point, for about thirty miles, the country is occupied by a succession of parallel ridges, striking the boundary nearly at right angles, and separated by deep, and sometimes impassable chasms. It then falls abruptly to near the level of the sea. The remainder of the line stretches across the desert of shifting sand at the head of the Gulf of California, destitute, for the most part, of both water and vegetation.

The following is the order in which are arranged the subjects embraced in the determination of the line:

1. The longitude of Camp Riley, near the Initial Point.
2. The longitude of Camp near the junction of the Gila and Colorado.
3. The latitude of Camp Riley, near the Initial Point.
4. The latitude of Camp near the junction of the Gila and Colorado.
5. Transfer of the latitude and longitude of Camp Riley, by triangulation, to the Initial Point.
6. Azimuth of straight line from Initial Point, on Pacific, to junction of Gila and Colorado.

Numbers 1, 3, 5, and 6 are by myself. Numbers 2 and 4 are by Lieutenant Whipple.

The tracing of the line on the ground was partly by myself and Lieutenant Whipple, but chiefly by Captain E. L. F. Hardcastle, corps topographical engineers.

The computation of the azimuth of the line was made in the field. In this computation the earth was supposed to be a spheroid of revolution of the following dimensions, which are those determined by Bessel from all the measurements up to that time, (1849,) and the elements given by him were converted into English measure by adopting the following value of the metre, viz:

39.6850 inches; logarithm	1.5951741293.
Equatorial radius	= 6974129.339 yards.
Polar radius	= 6950815.059 "

I am indebted to Professor Airy for the observations at Greenwich for 1849; and for the recomputation of the longitude and the application of the correction due to the corresponding observations on moon and moon culminating stars, I am indebted to the assistance of Professor J. S. Hubbard, of the National Observatory.

I. LONGITUDE OF CAMP RILEY, NEAR THE INITIAL POINT.

The observations with the transit instrument have been reduced in the following manner:

The equatorial intervals of the transit wires having been determined as accurately as possible, the imperfect transits were corrected, by applying to the mean of the observed wires the mean of their equatorial intervals, multiplied by the secant of the stars' declination.

For circum-polar stars, each wire was reduced separately, and the mean of the results taken. In the case of the moon, allowance was made for its motion by the method and tables of Bessel. (Tabulæ Regiomontanæ, pp. LII and 537.)

Denoting by a the constant of correction for azimuth of the instrument, by b the constant for level, and by c that for collimation, and by d the star's right ascension, δ its declination and z its zenith distance, and by t the chronometer time of its transit, and by $\Delta\, t$ the correction of the chronometer at the time t, we have the known formula—

$$\alpha = t + \Delta\, t + a \sin. z. \sec. \delta + b. \cos. z. \sec. \delta + c. \sec. \delta.$$

If φ denote the latitude of the observer, and if

$$m = b. \cos. \varphi + a. \sin. \varphi,$$
$$n = b. \sin. \varphi - a. \cos. \varphi,$$

the expression above becomes—

$$\alpha = t + \Delta\, t + m + n. \tan. \delta + c. \sec. \delta,$$

or

$$\alpha = t + \Delta\, t + m + (n + c.) \tan. \delta + c. (\sec. \delta - \tan. \delta)$$

which last form has been employed in the reductions.

In the observations at Camp Riley, $c = o$ for nearly the whole series, and is small enough at all times to have no effect in the last term of the formula; in the other series, one or two cases occur where it has been necessary to take this last term into account.

Where, as in the present case, only the right ascension of the body is wanted, the quantities $\Delta\, t$ and m being constant for the evening, may be combined together, and then the last term of

one equation, always small, and vanishing at no great distance from the equator, being introduced when necessary, and the requisite correction for the chronometer rate being applied, it is evident that but two equations are necessary for the determination of the unknown quantities. One is generally furnished by a circum-polar star; the other by the mean of the equations, corresponding to all the stars near the moon's path, in order the more completely to remove all chance of constant error from the desired result. The equations being solved, furnish the quantities given below, and which have been applied to the observations.

The first column contains the date; the second the name of the object observed; the third shows the position of the instrument, (lamp east or west.) Next follow columns 4, 5, 6, 7, 8, 9, 10, the seconds of observed transit, and column 11, the mean of the transit over as many wires as have been observed. Column 12 contains the correction to be applied to this mean for an imperfect transit; column 13 the correction for instrumental error, or the quantity $(n + c)$ tan. $\delta + c$. (sec. δ — tan. δ,) the last term of which is generally equal to o; and column 14 gives the correction of chronometer, and the constant term of instrumental correction, or the quantity $\Delta t + m$.

In cases where a mean-time chronometer has been used, this column includes also the reduction of mean to sidereal time, the quantities in all the preceding columns being in mean time. In column 15 is given the sum of the quantities; in columns 11, 12, 13, and 14 are the observed right ascension of the object; and the last column shows the tabular right ascension, taken in the order of preference from the Nautical Almanac, the Greenwich Twelve-year Catalogue, or the Catalogue of the British Association.

The next step was to deduce the required corrections of the assumed longitude of the place, by comparing the observed AR. of the moon with that corresponding to the assumed longitude already determined very approximately by computations in the field. For this purpose, the tabular AR. was interpolated from the moon culminating list of the Nautical Almanac, using fourth differences, and it was found that the assumed longitude corresponded perfectly to the results from the uncorrected tabular place of the moon. But the extracts from the observations at Greenwich, given below, show a correction of the latter to be necessary; and this being applied, the corresponding correction of the assumed longitude was determined and also applied.

Constant values employed in the reductions.

OBSERVATORY AT CAMP RILEY.

Equatorial intervals of transit wires.

I.	II.	III.	IV.	V.	VI.	VII.
s.	s.	s.	s.	s.	s.	s.
+ 51.163	+ 33.971	+ 17.165	+ 0.22	— 17.092	— 34.089	— 51.141.

	$n + c.$	$\Delta t + m.$
	s.	s.
July 27....	0.000	+ 11.99
28....	0.000	+ 12.50
29....	0.000	+ 12.48
30....	0.000	+ 12.45
31....	— 0.770	+ 12.20
Aug. 2....	— 0.726	+ 12.63
3....	— 0.726	+ 10.85
26....	— 1.852	+ 6.32
27....	— 2.694	+ 6.30
28....	— 2.231	+ 6.28
29....	— 1.778	+ 5.87
Sept. 3....	— 2.613	+ 1.84
4....	— 2.427	+ 0.49

	$n + c$	$\Delta t + m.$
	s.	h. m. s.
*Sept. 5...	+ 2.716	— 2 25 29.02
24...	+ 1.388	— 2 24 54.55
27...	+ 1 041	— 2 24 47.68
28...	+ 0.792	— 2 24 45.66
29...	+ 1.125	— 2 24 43.83
30...	+ 1.204	— 2 24 42 23
Oct. 23...	+ 0.934	— 2 23 54.74
25...	+ 1.471	— 2 23 48.95
28...	+ 1.128	— 2 23 40.42
29...	+ 1.764	— 2 23 38.85
Nov. 1...	+ 1.764	— 2 23 31.26
2...	+ 1.764	— 2 23 28.09
5...	0.000	— 2 23 22.54

OBSERVATORY NEAR JUNCTION OF THE GILA AND COLORADO RIVERS.

Equatorial intervals of transit wires.

I.	II.	III.	IV.	V.	VI.	VII.
s.	s.	s.	s.	s.	s.	s.
+ 52.790	+ 35.078	+ 17.467	+ 0.44	— 17.489	— 35.180	— 52.710.

	$n + c.$	$\Delta t + m.$
	s.	m. s.
Oct. 3....	— 1.339	+ 41.79
4....	— 1.026	+ 39.05
5....	— 0.450	+ 12 2.06
6....	— 0.000	+ 31.52
7....	— 0.878	+ 29.66
23....	— 29.100	+ 8.79
24....	— 1.410	— 12.15
25....	— 0.450	— 27.80
26....	— 0.437	— 29.86
27....	— 0.147	— 34.19
28....	— 0.297	— 36.50
29....	— 0.607	— 39.04
30....	— 1.435	— 41.56
31....	— 1.238	— 45.01

	$n + c.$	$\Delta t + m.$
	s.	m. s.
Nov. 1....	— 0.802	— 45.76
2....	— 0.199	— 49.99
3....	0.000	— 52.07
4....	0.000	— 54.11
5....	— 0.411	— 55.17
6....	0.000	— 57.31
20....	0.773	+ 12 22.04
22....	0.000	— 1 29.88
23....	0.000	— 1 32.22
24....	+ 0.672	— 1 35.09
25....	0.000	— 1 37.36
27....	— 4.370	+ 12 25.83
29....	— 4.270	— 1 42.73

* The value of Δt adopted for the mean-time chronometer being the complement of the time value, it becomes necessary to change the sign of $(n + c.)$

Longitude of Camp Riley: By William Hemsly Emory.

DATE.	OBJECT.	LAMP.	CHRONOMETER TIMES OF TRANSIT. I.	II.	III.	IV.	V.	VI.	VII.	MEAN OF OBS'D WIRES	CORRECTION FOR— Imperfect transits.	Instrument.	Chronometer.	OBSERVED A.R.	TABULAR A.R.
1849.			s.	s.	s.	s.	s.	s.	s.	h. m. s.	m. s.	s.	s.	h. m. s.	s.
July 26	ε Bootis		16.0	35.0	54.0	13.2	32.5	52.0	11.2	14 38 13.41	....	0 00	+ 11.14	14 38 24.55	24.61
	α^2 Libræ		29.2	47.0	5.0	22.5	40.5	58.5	16.0	14 42 23.67	....	0.00	11.14	14 42 33.81	33.74
27	Moon, 1st L....		......	......	......	......	39.5	57.5	15.0	15 2 57.33	— 38.66	0.00	+ 11.96	15 2 33.63	......
	β Libræ..........		......	9.2	26.2	43.4	1.0	18.0	35 0	15 8 52.13	— 8.63	0.00	11.97	15 8 55.47	[illegible]
	α Serpentis.......		[illegible]	6.0	[illegible]	38.8	[illegible]	14.0	28.0	*15 36 39.37	....	0.00	11.99	15 36 51.36	51.69
	θ Libræ..........		11.6	29.2	46.4	4.0	22.4	39.6	54.8	15 45 4.00	....	0.00	11.99	15 45 15.99	16.14
28	α Serpentis	W.	47.2	5.0	22.0	39.0	56.5	13.5	30.5	15 36 39.10	....	0.00	+ 12.49	15 36 51.59	51.67
	θ Libræ		......	28.2	[illegible]	4.0	22 0	39.2	56.8	15 45 12.70	— 8.88	0.00	12.49	15 45 16.31	16.13
	Moon, 1st L....		43.0	1.5	19.5	37.6	[illegible]	13.5	32.0	15 51 37.59	....	0 00	12.49	15 51 50.08	......
	β^1 Scorpii		[illegible]	54.0	12.0	29.6	47.8	6.5	24.0	15 56 29 96	....	0.00	12.49	15 56 42.45	42.04
	δ Ophiuchi		24.5	42.2	58.6	16 0	33 0	50.0	7.5	16 6 15.97	....	0.00	12.50	16 6 28.47	[illegible]
	α Scorpii.........		2.0	20.6	40.8	59.2	18.4	36.4	53.8	16 19 58.74	....	0.00	12.50	16 19 11.24	11.87
	(5579)...		46.8	4.2	22.8	40.0	58.8	16 8	34.2	16 32 40.52	....	0 00	12.50	16 32 53.02	53.11
	η Ophiuchi.......		......	......	15.5	33.2	50.8	8.6	26.0	17 1 50.82	— 17.67	0.00	12.51	17 1 45.66	[illegible]
29	Moon, 1st L....	W.	46.0	5.0	......	41.5	58.5	17.5	35.4	16 41 43.98	— 3.06	0.00	+ 12.47	16 41 53.39	......
	*Anonymous....		......	......	51.5	9.5	27.0	44.5	2.5	17 2 27.00	— 17.67	0.00	12.47	17 2 21.80	......
30	(5579)	W.	47.0	5.0	23.0	41.0	59.0	......	34.0	16 32 34.83	+ 5.95	0.00	+ 12.45	16 32 53 23	[illegible]
	η Ophiuchi.......		[illegible]	[illegible]	[illegible]	[illegible]	51.0	8.6	26 0	17 1 33.09	....	0.00	12.45	17 1 45.54	45.78
	Moon, 1st L....		45.2	4.0	22.2	40.5	58.4	17.2	36.2	17 32 40.53	....	0.00	12.45	17 32 52.98	......
31	(5579)		47.5	5.0	23.0	40.5	58.5	15.5	33.5	16 32 40.50	....	+ 0.25	+ 12.21	16 32 52.96	53.07
	α Herculis		42.8	0.8	18.2	36.2	53.2	11.2	29.0	17 7 35.92	....	— 0.20	12.20	17 7 47.92	47.85
	Moon, 1st L....		38.0	51.0	9.6	28.0	46.0	4.5	23.0	18 24 27.87	....	+ 0.28	12.19	18 24 40.34	......
	α Lyræ...........		......	......	......	......	......	24.0	46.0	18 32 35.00	— 54.57	— 0.63	12.19	18 31 51.99	51.95
Aug. 1	α Serpentis.......	W.	49.2	6.0	[illegible]	40.4	57.2	14.8	31.6	15 36 40.34	....	— 0.09	+ 11.76	15 36 52.01	[illegible]
	β^1 Scorpii.........		36.0	54.0	10.4	30.0	48.8	6.4	24.4	15 56 30.00	....	+ 0.28	11.76	15 56 42.04	41.99
	δ Ophiuchi		[illegible]	42.0	58.4	......	31.6	50.0	8.0	16 6 15.87	....	+ 0.05	11.76	16 6 27.68	[illegible]
2	γ Draconis	W.	33.5	2.0	29.0	56.5	23.6	51.0	18.5	17 52 56.30	....	— 0.78	+ 12.63	17 53 8.15	[illegible]
	μ^1 Sagittarii.......		......	57.0	15.2	33.5	52.0	10.0	29.0	18 4 42.78	— 9.14	+ 0.24	12.63	18 4 46.51	[illegible]
	δ Ursæ Minoris...		......	36.0	24.0	12.0	59.0	47.5	37.0	18 23 35.92	—2 23.97	— 10.48	12.63	18 21 14.10	13.50
	51 (Hev.) Cep., S.P.		37.0	32.5	32.0	23.0	16.0	15.5	......	18 24 26.00	+2 57.32	+ 12.96	12.63	18 27 48.91	52.21
	β Lyræ		......	39.5	59.5	20.0	40.5	......	20.0	18 44 29.92	— 10.19	— 0.41	12.63	18 44 31.95	[illegible]
	ζ Aquilæ		25.5	42.5	......	18.2	35.5	53.0	10.8	18 58 17.93	....	— 0.15	12.63	18 58 30.41	30.65
	ρ^1 Sagittarii........		51.4	9.0	27.0	45.0	2.8	20.5	38.3	19 12 44.86	....	+ 0.20	12.63	19 12 57.69	57.54
	e^1 Sagittarii........		1.0	18.5	36.5	54.0	12.0	30.0	47.5	19 31 54.21	....	+ 0.19	12.63	19 31 7.03	6.73
	ζ Sagittarii........		......	37.5	55.5	13.0	31.0	48.0	6.5	19 49 21.92	— 8.87	+ 0.18	12.63	19 49 25.86	25.81
†	Moon, 1st L ...	E.	16.4	34.4	52.8	11.2	29.2	47.5	6.0	20 9 11.07	....	+ 0.19	12.63	20 9 23.89	......
	ρ Capricorni		10.8	[illegible]	46.5	4.5	[illegible]	40.0	58.0	20 20 4.40	....	+ 0.21	12.63	20 20 17.24	17.31
	μ Aquarii.........		[illegible]	46.0	3.0	20.2	37.5	55.0	12.0	20 44 20.31	....	+ 0.11	12.63	20 44 33.05	[illegible]
3	α^1 Capricorni......	E.	......	33.2	50.0	8.0	26.5	......	1.0	20 9 11.74	— 3.52	+ 0.18	+ 10.87	20 9 19.27	19.19
	α^2 Capricorni......		......	56.7	13.5	31.5	50.0	....	24.5	20 9 35.24	— 3.53	+ 0.18	10.87	20 9 42.77	43.06
	ρ Capricorni......		12.5	30.0	48.4	6.0	24.0	42.0	0.2	20 20 6.14	....	+ 0.26	10.85	20 20 17.25	17.29
	η Capricorni......		45.8	3.8	21.8	40.0	......	......	......	20 55 12.85	+ 27.30	+ 0.29	10.83	20 55 51.27	[illegible]
	Moon, 1st L....		......	49.0	......	......	......	1.6	......	21 1 25.39	+ 0.07	+ 0.22	10.82	21 1 36.41	......
4	ε Ursæ Minoris...	E.	13.5	21.8	28.0	35.0	42.0	49.5	56.0	17 1 35.11	....	— 5.78	+ 9.99	17 1 39.32	[illegible]
	β Draconis........		30.5	58.0	26.5	54.5	22.8	50.2	18.5	17 26 54.43	....	— 1.02	9.98	17 27 3.39	3.27
	58 Ophiuchi		......	39.0	57.0	15.6	[illegible]	52.0	10.4	17 34 24.67	— 9.17	+ 0.31	9.98	17 34 25.79	[illegible]
	4 Sagittarii		31.0	49.5	8.5	27.0	45 4	4.4	......	17 50 17.63	+ 9.32	+ 0.35	9.97	17 50 37.27	[illegible]
	γ Draconis........		......	.....	......	58.8	26.4	53.6	21.5	17 53 40.08	— 41.10	— 0.98	9.97	17 53 7.97	[illegible]
	μ^1 Sagittarii.......		......	......	......	36.5	54.5	12.8	......	18 4 54.60	— 18.28	+ 0.30	9.97	18 4 46.59	[illegible]
	δ Ursæ Minoris...		....	......	......	16.0	......	......	......	18 21 16.00	— 0.37	— 13.18	9.96	18 21 12.41	[illegible]
	51 (Hev.) Cephei..		38.0	......	......	27.0	......	......	......	18 18 32.50	+8 51.47	+ 16.30	9.96	18 27 50.23	[illegible]
	α Lyræ		37.0	59.0	21.0	42.6	4.5	26.8	48.0	18 31 42.70	....	— 0.63	9.96	18 31 52.03	[illegible]
	β Lyræ . . .		22.2	43.0	2.8	......	......	4.4	24.5	18 44 19.38	+ 4.11	— 0.51	+ 9.95	18 44 32.93	32.71

* Observed by mistake for η Ophiuchi.

† Instrument reversed.

Longitude of Camp Riley—Continued.

DATE.	OBJECT.	LAMP.	CHRONOMETER TIMES OF TRANSIT. I.	II.	III.	IV.	V.	VI.	VII.	MEAN OF OBS'D WIRES	CORRECTION FOR— Imperfect transits.	Instrument.	Chronometer.	OBSERVED A.R.	TABULAR A.R.
1849.			s.	s.	s.	s.	s.	s.	s.	h. m. s.	m. s.	s.	s.	h. m. s.	s.
Aug. 19*	ε Ursæ Minoris	W.	......	20.4	27.6	34.8	42.4	49.0	56 0	17 2 38 37	−1 3.51	− 6.99	+ 7.47	17 1 35.34	36.61
	β Draconis		32 6	0.4	28.0	56.4	24.4	52.4	20.4	17 26 56.37	....	− 1.23	7.47	17 27 2.61	2.86
	58 Ophiuchi		22.4	40.4	58.8	17.4	35.6	54.0	12.4	17 34 17.30	....	+ 0.37	7.47	17 34 25.14	25.53
	4 Sagittarii		33.6	51.6	10.0	28.6	47.2	6.0	25.0	17 50 28.86	....	+ 0.42	7.47	17 50 36.75	37.09
	μ^1 Sagittarii		44.0	2.0	20.4	38.8	57.2	15.4	33.2	18 4 38.71	....	+ 0.37	7.47	18 4 46.55	46.53
	δ Ursæ Minoris		......	41.6	30.4	16.6	3.8	49.2	38 4	18 23 40.00	−2 23.92	− 15.96	7.47	18 21 7.59	8.20
	ζ Aquilæ		......	......	......	......	40.4	58.0	16.0	18 59 58.13	− 35.10	− 0.23	7.47	18 59 30.27	30.53
	δ Aquilæ		57.0	14.0	30.8	48.0	5.6	22 4	38.8	19 17 48.09	....	− 0.05	7.47	19 17 55.51	55.54
	γ Aquilæ		8.4	26.0	43.2	0.4	18.0	34.6	51.6	19 39 0.31	....	− 0.17	7.47	19 39 7.61	7.36
	α Aquilæ		28.6	45.5	3.2	20.4	37.6	54 8	12.0	19 43 20.30	....	− 0.14	7.47	19 43 27.63	27.48
	α^1 Capricorni		19.0	36.0	53.8	11.2	28.5	46.0	3.5	20 9 11.20	....	+ 0.22	7.47	20 9 18.89	19.20
	α^2 Capricorni		43.0	1 0	18.0	35.2	52.5	9.0	27.8	20 9 35.21	....	+ 0.22	7.47	20 9 42.90	43.07
	α Cygni		2.0	26.0	50.0	14.0	38.0	2.4	26.5	20 36 14 13	....	− 0.94	7.47	20 36 20.66	20.11
	61^1 Cygni		59.6	22.0	42.8	4.8	26.2	48.0	9.6	21 0 4.72	....	− 0.74	7.47	21 0 11.45	11.07
	ζ Cygni		27.5	48.0	8.0	26.8	48.0	6.0	26.0	21 6 26.90	....	− 0.54	7.47	21 6 33.83	33.59
	ι Capricorni		51.4	9.5	26.4	44.8	3.0	20.6	38.0	21 13 44.81	....	+ 0.30	7.47	21 13 52 58	52.67
26	η Ophiuchi	W.	45.5	3.0	20.5	38.4	56.0	13.5	31.5	17 1 38.34	....	+ 0.51	+ 6.32	17 1 45.17	45.42
	α Herculis		49.0	6.8	23.8	41.8	59.5	16.8	34.5	17 7 41.74	....	− 0.48	6.32	17 7 47.58	47.47
	Moon, 1st L		7.0	25.4	43.5	2.0	20.2	38.4	57.0	17 13 1.93	....	+ 0.60	6.32	17 13 8.85	......
	58 Ophiuchi		22.8	41.4	59.8	......	36.0	......	......	17 33 55.00	+ 22.91	+ 0.73	6.32	17 34 24.96	25.42
	μ^1 Sagittarii		......	......	21.5	39.8	57.8	......	34.2	18 4 53.32	− 13.68	+ 0.71	6.32	18 4 46.67	46.43
	λ Sagittarii		37.8	57.0	16.0	35 0	53.8	12.5	31.4	18 18 34.80	....	+ 0.88	6.32	18 18 42.00	41.65
	α Lyræ		41.5	3 5	24.5	46.5	8.4	30.0	52.0	18 31 46.63	....	− 1.48	6.32	18 31 51.47	51.55
	ν^1 Sagittarii		3 6	22.0	40.0	58.6	17.5	35.5	54.0	18 44 58.74	....	+ 0.78	6.32	18 45 5.84	5.73
	ζ Aquilæ		32.4	49.5	7.0	24.5	42.0	59.5	17.0	18 58 24.56	....	− 0.45	6.32	18 58 30.43	30.45
27	η Ophiuchi	W.	45.8	3.0	20.8	38.0	56.0	13.6	31.5	17 1 38.38	....	+ 0.75	+ 6.30	17 1 45.43	45.40
	α Herculis		49.0	6.5	23.8	41.5	59.5	17.0	34.4	17 7 41.67	....	− 0.70	6.30	17 7 47.27	47.45
	θ Ophiuchi		42.4	1.5	20.4	39.0	58.0	16.8	35.4	17 12 39.07	....	+ 1.25	6.30	17 12 46.62	46.74
	α Ophiuchi		59.6	17.0	34 0	51.5	9.5	26.5	43.5	17 27 51.66	....	− 0.61	6.30	17 27 57.35	57.36
	58 Ophiuchi		23.0	41.0	59.4	18.0	36.5	54.8	13.0	17 35 17.96	....	+ 1.06	6.30	17 35 25.32	25.40
	4 Sagittarii		33.5	52.5	11.0	29.4	48.0	7.0	25.4	17 50 29.54	....	+ 1.19	6.30	17 50 37.03	36.97
	Moon, 1st L		33.0	51.4	10.0	28.2	47.0	5.4	23.6	18 4 28.37	....	+ 0.92	6.30	18 4 35.59	......
	λ Sagittarii		37.5	56.8	15.0	34.0	53.4	12.0	30.5	18 18 34.17	....	+ 1.28	6.30	18 18 41.75	41.64
	ζ Aquilæ		32.0	49.4	7.2	25.0	42.5	59.8	17.8	18 58 24.96	....	− 0.65	6.30	18 58 30.61	30.43
28	μ^1 Sagittarii	W.	44.0	2.6	21.8	39.2	57.0	16.0	34.0	18 4 39.23	....	+ 0.86	+ 6.28	18 4 46.37	46.40
	λ Sagittarii		......	56.6	15.2	34.0	53.2	12.5	30.5	18 18 43 67	− 9.45	+ 1.06	6.28	18 18 41.56	41.62
	α Lyræ		41.2	3.4	25.2	46.8	9.0	30.6	52.5	18 31 46.96	....	− 1.78	6.28	18 31 51.46	51.51
	Moon, 1st L		34.0	52.2	11.0	29.4	48.0	6.0	......	18 56 20.10	+ 9.23	+ 0.76	6 28	18 56 36.37	......
	π Sagittarii		......	6.5	24.0	42.4	0.5	......	......	19 0 33.35	+ 9.14	+ 0.87	6.28	19 0 49 64	49.46
	γ Aquilæ		9.4	26.8	......	......	......	......	......	19 38 18.10	+ 43.26	− 0.40	6.28	19 39 7.24	7.28
*29	4 Sagittarii	E.	33.4	52 4	11.0	29.4	48.2	6.8	25.2	17 50 29.51	....	+ 0.78	+ 5.87	17 50 36.16	36.94
	μ^1 Sagittarii		45.0	3.0	21.4	39.4	58.0	16.5	33.8	18 4 39.51	....	+ 0.69	5.87	18 4 46.07	46.39
	λ Sagittarii		38.6	57.0	16.0	34.6	53.6	12.5	31.5	18 18 34.83	....	+ 0.85	5.87	18 18 41.55	41.61
	α Lyræ		42.0	4.0	25.0	47.2	9.4	31.0	53.0	18 31 47.37	....	− 1.42	5.87	18 31 51.82	51.59
	ο Sagittarii		......	57.5	16.0	......	......	......	29.0	18 55 34.17	0.00	+ 0.72	5.87	18 55 40.76	40.62
	ζ Aquilæ		......	......	......	25.2	42.6	0.0	17.5	18 58 51.32	− 26.32	− 0.43	5.87	18 58 30.44	30.41
	ρ Sagittarii		57 2	16.0	33.8	51.2	......	......	......	19 12 24.55	+ 26.92	+ 0.58	5.87	19 12 57.92	57.37
	δ Aquilæ		57.8	15.2	31.8	......	6.5	23.2	40.0	19 17 49.08	0.00	− 0.09	5.87	19 17 54.86	55.44
	γ Aquilæ		9.5	27.0	44.0	1.8	19.2	36.0	53.2	19 39 1.53	....	− 0.32	5.87	19 39 7.08	7.28
	Moon, 1st L		56.8	15.4	34.0	52.6	11.5	30.0	48.0	19 48 52.61	....	+ 0.57	5.87	19 48 59.05	......
	α^1 Capricorni		21.0	38.0	56.0	13.5	31.0	......	6.0	20 9 7.58	+ 5.83	+ 0.41	5.87	20 9 19.69	19.15
	α^2 Capricorni		44.5	3.2	20.2	37.6	......	......	29.5	20 9 27.00	+ 10.51	+ 0.41	5.87	20 9 43.79	43.02
	β Capricorni		34.8	52.4	10.0	27.6	45.0	3.0	20.6	20 12 27.62	....	+ 0.48	5.87	20 12 33.96	34.12
	α Cygni		3.3	27.0	50.0	15.0	39.2	3.5	27.5	20 36 15.07	....	− 1.76	5.87	20 36 19.18	20.02
30	μ^1 Sagittarii	W.	45.2	3.5	21.5	39.8	58.2	16.5	34.5	18 4 39.89	....	+ 0.80	+ 5.48	18 4 46.17	46.37
	δ Ursæ Minoris		......	57.5	46.5	......	......	......	......	18 14 22.00	+7 11.69	− 35.14	5.48	18 21 5.03	4.22
	α Lyræ		42.6	4.8	26.0	47.8	9 8	31.0	53.0	18 31 47.86	....	− 1.67	+ 5.48	18 31 51.67	51.47

* Instrument reversed.

Longitude of Camp Riley—Continued.

DATE.	OBJECT.	LAMP.	CHRONOMETER TIMES OF TRANSIT. I.	II.	III.	IV.	V.	VI.	VII.	MEAN OF OBS'D WIRES.	CORRECTIONS FOR Imperfect transits.	Instrument.	Chronometer.	OBSERVED A.R.	TABULAR A.R.
1849.			s.	s.	s.	s.	s.	s.	s.	h. m. s.	m. s.	m. s.	m. s.	h. m. s.	s.
Sept. 1	e^1 Sagittarii	W.	......	......	......	2.0	20.0	37.5	55.0	19 32 28.62	— 26.69	+ 0.66	+ 3.97	19 32 6.56	6.57
	γ Aquilæ		12.0	29.0	46.8	4.0	21.4	37.8	55.8	19 39 3.83	....	— 0.40	3.97	19 39 7.40	7.27
	α Aquilæ		31.8	49.4	6.5	23.5	40.5	57.8	15.4	19 43 23.50	....	— 0.33	3.97	19 43 27.14	27.39
	g^1 Sagittarii.......		27.8	45.5	3.2	21.2	39.0	57.0	14.5	19 49 21.17	....	+ 0.63	3.97	19 49 25.77	25.69
	α Cygni		6.0	30.8	54.4	18.0	42.2	6.0	30.4	20 36 18.26	....	— 2.19	3.97	20 36 20.04	20.01
3	π Sagittarii.......	W.	51.6	10.0	28.0	46.4	4.8	23.4	41.2	19 0 46.48	....	+ 1.02	+ 1.98	19 0 49.48	[illegible]
	ρ^1 Sagittarii.......		0.2	18.4	36.5	54.5	12.4	30.0	48.4	19 12 54.34	....	+ 0.86	1.96	19 12 57.16	57.30
	δ Aquilæ		2.5	19.4	36 0	53.4	10.5	27.2	44.4	19 17 53.34	....	— 0.13	1.95	[illegible]	[illegible]
	γ Aquilæ		13.6	31.0	48.4	6.0	23.2	40.0	57.8	19 39 5.72	....	— 0.47	1.94	19 39 7.19	7.22
	α Aquilæ		......	51.2	8.8	26.0	42.6	0.4	17.4	19 43 34.40	— 8.62	— 0.39	1.93	19 43 27.32	27.35
	g Sagittarii		30.0	47.0	5.0	23.0	40.5	58.0	16.4	19 49 22.84	....	+ 0.74	1.93	19 49 25.51	25.67
	α^1 Capricorni......		24.0	41.5	59.0	17.0	34.0	51.6	9 2	20 9 16.61	....	+ 0.60	1.92	20 9 19.13	19.11
	α^2 Capricorni......		48.0	5.2	23.0	40.0	57.5	16.0	33.0	20 9 40.39	....	+ 0.60	1.92	[illegible]	[illegible]
	75 Draconis........		......	13.5	2.0	50.0	......	25.0	13.5	20 38 32.80	— 43.08	— 16.31	1.90	[illegible]	[illegible]
	76 Draconis........		31.5	32.4	35.2	36.6	39.2	40.4	43.0	20 53 36.90	....	— 18.51	1.89	20 53 20.28	19.78
	β Cephei		23.5	12.5	1.8	52.0	42.0	31.0	21.0	21 26 51.97	....	— 7.14	1.87	21 26 46.70	46.49
	7663		42.2	10.4	37.5	6.0	33.0	2.4	28.8	21 54 5.73	....	— 13.24	1.85	21 53 54.34	50.33
	3495, S. P.......		......	......	46.5	0.4	17.5	31.8	45.4	22 9 16.32	—3 16.23	+ 29.96	1.84	[illegible]	[illegible]
	λ Aquarii		53.0	10.4	27.4	44.6	2.0	19.2	36.2	22 44 44.69	....	+ 0.38	1.81	22 44 46.88	46.84
	α Piscis Australis		18.0	37.5	57.8	17.2	36.5	56.2	16.6	22 49 17.12	....	+ 1.53	1.81	22 49 20.46	20.56
	α Pegasi		23.4	41.4	58.8	16.5	34.0	51.5	9.0	22 57 16.37	....	— 0.67	[illegible]	22 57 17.50	17.47
	φ Aquarii		39.0	56.4	13.4	30.4	47.6	4.8	22.4	23 6 30.57	....	+ 0.31	1.79	23 6 32 67	32.82
	96 Aquarii		......	......	18.0	35.0	52.0	9.0	26.4	23 11 52.08	— 17.12	+ 0 27	1.78	23 11 37.01	[illegible]
	ι Piscium		21.6	37.8	55.2	12.5	29.8	47.0	4.2	23 32 12.58	....	— 0.22	1.76	23 32 14.12	13.97
	20 Piscium		20.8	37.6	55.0	11.5	28.5	45.8	3.0	23 40 11.74	....	+ 0.16	1.76	23 40 13.66	13.48
	27 Piscium		6.4	23.0	40.0	57.2	14.5	31.5	48.7	23 50 57.33	....	+ 0.20	1.75	23 50 59.28	59.34
	33 Piscium		45.5	2.6	20.0	37.0	54.0	11.2	28.2	23 57 36.93	....	+ 0.30	1.75	[illegible]	39.17
	α Andromedæ		......	......	18.8	38.0	57.5	17.0	.....	47.82	— 9.65	— 1.40	1.75	38.52	38.69
	γ Pegasi..........		36.6	54.8	12.2	29.4	47.4	4.8	22.5	5 29.67	....	— 0.67	1.75	5 30.75	30.84
	Moon, 2d L.....		11.5	28.5	46.4	4.0	21.5	38.5	56.4	12 3.83	....	+ 0.06	1.74	12 5.63	......
	10 Ceti		......	......	37.0	54.0	11.0	28.0	45.0	19 11.00	— 17.03	+ 0.04	1.74	[illegible]	[illegible]
	13 Ceti		38.0	55.2	12.4	29.6	46.5	3.6	21.0	27 29.90	....	+ 0.20	1.73	27 31.83	31.17
	β Ceti		6.5	24.5	42.0	......	18.5	35.8	......	35 51.22	+ 9.00	+ 0 89	1.73	36 2.84	2.91
	δ Piscium		1.0	18.4	35.5	52.5	10.0	27.0	44.0	40 52 64	....	— 0.31	1.72	[illegible]	[illegible]
	20 Ceti		27.0	44.0	1.0	18.5	35.4	52.4	10.0	45 18.33	....	+ 0.09	1.71	45 20.13	20.19
	Polaris..........		......	......	24.0	26.4	17.0	13.0	12.6	1 18 18.60	—10 53.80	—1 40.00	1.70	1 5 46.50	50.78
4	27 Piscium	W.	7.4	24.4	41.4	59.6	16.0	32 5	49.8	23 50 58.59	....	+ 0.19	+ 0.55	[illegible]	[illegible]
	33 Piscium		47.0	4.0	21.4	38.0	55.5	12.6	29.6	23 57 38.30	....	+ 0.28	0.54	23 57 39.12	39.10
	γ Pegasi..........		38.0	55.6	13.4	31.0	48.5	6.2	23 6	5 30.90	....	— 0.62	0.54	5 30.82	30.83
	10 Ceti		4.0	21.8	38.4	55.2	12 4	29.0	46.0	18 55.26	....	+ 0.04	0.52	18 55.82	55.54
	13 Ceti		39.4	56.4	13.5	30.6	47.6	5.0	......	27 22.08	+ 8.55	+ 0.19	0.51	27 31.33	31.18
	β Ceti		8.0	25.6	43.4	2.0	20.0	37.4	55.4	36 1.70	....	+ 0.83	0.51	36 3.04	2.93
	δ Piscium		2.4	19.4	36.4	53.8	11.0	28.0	45.0	40 53.71	....	— 0.29	0.50	40 53.92	53.88
	ε Piscium		18.0	35.0	52.0	9.4	26.4	43.4	0.6	55 9.26	....	— 0.30	0.49	55 9.45	9.34
	c Piscium		46.8	4.0	20.4	38.0	55.0	12.4	29.6	1 0 38.17	....	— 0.21	0.49	1 0 38.45	39.05
	Moon, 2d L. ...		......	24.0	41.5	59.0	16.5	34.0	51.4	1 5 7.73	— 8.73	— 0.13	0.48	1 4 59.35	......
	μ Piscium		27.8	44.8	2.0	19.0	36.0	53.4	10.6	1 22 19.09	....	— 0.23	0.46	1 22 19.32	19.16
	ν Piscium		45.8	2.8	20.0	36.8	54.0	11.2	28.0	1 33 36.94	....	— 0.21	0.45	1 33 37.18	37.19
	ο Piscium		......	......	11.0	28.0	45.4	2.8	20.0	1 37 45.44	— 17.21	— 0.36	0.45	1 37 28.32	27.94
	φ Phœnicis.......		......	......	41.5	5.0	28.5	52.0	15.0	1 48 28.40	— 23.37	+ 2.28	0 44	1 48 7.75	8.00
	α Arietis		48.0	6.8	25.0	43.5	2.0	20.0	38.5	1 58 43.40	....	— 1.02	0.43	1 58 42.81	43.07
	μ Fornacis........		15.4	35.5	55.0	15.4	34.4	55.0	15.5	2 6 15.31	....	+ 1.48	0.42	2 6 17.21	17.34
*5	10 Ceti	W.	12.4	28.6	46.0	2.8	19.6	37.0	54.0	15 43 2.91	....	+ 0.04	+8 35 52.89	18 55.84	55.55
	13 Ceti		46.0	2.4	20.0	37.0	54.0	11.2	28.0	15 51 36.94	....	+ 0.21	35 54.30	27 31.45	31.19
	Polaris..........		......	47.6	30.8	24.0	......	......	......	16 20 30.80	+10 51.96	—1 44.00	36 0.58	1 5 39.34	51.68
	θ^1 Ceti		36.4	54.0	11.0	28.4	45.2	2.6	20.0	16 40 28.22	....	+ 0.43	36 2.32	1 16 30.97	31.07
	μ Piscium		25.0	42 0	59.0	16.0	33.4	50.4	7.6	16 46 16.20	....	— 0.26	36 3.27	1 22 19.21	19.17
	ν Piscium		41.0	58.2	15.2	32.4	49.4	6.6	23.6	16 57 32.34	....	— 0.22	+ 36 5.13	1 33 37.25	37.20

* Observed with mean-time chronometer No. 76.

Longitude of Camp Riley—Continued.

DATE.	OBJECT.	LAMP.	CHRONOMETER TIMES OF TRANSIT. I.	II.	III.	IV.	V.	VI.	VII.	MEAN OF OBS'D WIRES	CORRECTION FOR— Imperfect transits.	Instrument.	Chronometer.	OBSERVED A.R.	TABULAR A.R.
1849.			s.	s.	s.	s.	s.	s.	s.	h. m. s.	s.	s.	h. m. s.	h. m. s.	s.
Sept. 5	o Piscium	W.	31.2	48.2	5.8	23.0	40.0	57.2	14.0	17 1 22.77	....	— 0.[illegible]0	+ 36 5.75	1 37 28.12	27.95
	Moon, 2d L.		5.0	22.0	39.5	57.4	15.0	32.0	50.0	17 22 57.27	....	— 0.[illegible]	36 9.35	1 59 6.16	......
	ξ^1 Ceti		1.2	18.2	35.2	52.6	9.8	27.0	44.0	17 28 52.57	....	— 0.39	+ 8 36 10.27	2 5 2.45	2.74
	713 B. A. C.		......	2.0	23.4	44.4	5.4	27.0	48.0	17 34 55.03	— 10.60	+ 2.02	36 11.24	2 10 57.69	58.46
	ξ^2 Ceti		7.0	23.4	40.6	57.8	15.2	32 4	49.4	17 43 57.97	....	— 0.37	36 12.75	2 20 10.35	10.73
	783 B. A. C.		43.2	4.6	26.0	47.3	8 5	30.0	51.2	17 49 47.24	....	+ 2.05	36 13.72	2 26 3.01	4.09
	ι Eridani		19.0	41.5	4.0	26.5	48.6	11.4	33.4	17 58 26.34	....	+ 2.32	36 15.14	2 34 43.80	44.55
*7	δ Ursæ Minoris	W.	21.0	9.0	57.8	......	31.5	19.0	8.6	18 21 44.48	....	....	....	....	......
	51 (Hev.) Cephei		33.5	......	24.0	20.0	......	12.0	6.4	18 28 31.18	....	....	....	....	......
	6625 B. A. C.		19.0	30.5	42.4	55.0	7.0	18.8	31.0	19 14 54.81	....	....	....	....	......
	λ Ursæ Minoris		17.6	42.5	7.0	30.4	49.2	11.2	45.2	20 16 29.01	....	....	....	....	......
†17	γ^1 Sagittarii	W.	10.8	30 0	49.2	7.6	26.4	44.0	3.2	18 45 7.33	....	....	....	....	......
	ξ^2 Sagittarii		53.5	11.5	29.3	48.0	6.0	24.2	42.0	18 48 47.80	....	....	....	....	......
	o Sagittarii		47.0	5.8	24.0	42.0	0.4	18.6	37.0	18 55 42.11	....	....	....	....	......
	ζ Aquilæ		......	......	......	......	......	6.0	23.5	18 57 14.75	....	....	....	....	......
	δ Aquilæ		5.2	22.4	39.4	56.5	13.8	30.6	47.8	19 17 56.53	....	....	....	....	......
	β Cygni		41.8	1.5	21.0	40.2	59.6	18.8	38.0	19 24 40.13	....	....	....	....	......
	n^2 Sagittarii		38.4	58.0	16.8	35.4	54.0	13.4	31.8	19 27 35.40	....	....	....	....	......
	α Aquilæ		......	......	......	27.5	45.0	2.0	19.8	19 43 53.58	....	....	....	....	......
	c Sagittarii		29.0	48.4	8.0	27.0	46.5	6.0	24.8	19 53 27.10	....	....	....	....	......
18	ζ Aquilæ	W.	39.6	57.2	15.0	32.4	50.0	7.8	25.0	18 58 32.43	....	....	....	....	......
	β^1 Sagittarii		40.0	4.0	27.6	52.4	......	40.2	4.0	19 10 8.03	....	....	....	....	......
	β Cygni		44.0	3.6	23.0	41.8	1.6	20.6	39.8	19 24 42 06	....	....	....	....	......
	γ Aquilæ		17.8	35.0	52.4	9.6	27.0	44.0	1.4	19 39 9.60	....	....	....	....	......
	57 Sagittarii		......	54.0	12.2	30.4	48.4	6.5	24.5	19 43 39.33	....	....	....	....	......
	α^2 Capricorni		53.2	10.0	27.4	45.0	2.6	20.0	37.2	20 9 45.06	....	....	....	....	......
	π Capricorni		......	8.8	27.0	45.2	3.0	21.0	38.6	20 18 53.93	....	....	....	....	......
	γ Capricorni		37.5	55.5	13.8	31.5	49.5	8.0	25.8	20 31 31.61	....	....	....	....	......
	α Cygni		9.2	33.5	57 5	22.0	45.8	9.8	33.5	20 36 21.62	....	....	....	....	......
	μ Aquarii		[illegible]3.5	1.[illegible]	[illegible]	35.0	52.4	10.0	27.0	20 44 35.27	....	....	....	....	......
	η Capricorni		58.7	17.0	34.8	53.2	11.5	29.5	47.8	20 55 53.21	....	....	....	....	......
	ζ Cygni		36.0	56.0	15.5	35.3	55.0	14.7	34.0	21 6 35.20	....	....	....	....	......
‡20	δ Ursæ Minoris	E.	35.2	25.2	10.4	57.2	......	......	......	18 13 47.00	....	....	....	....	......
	δ Ursæ Minoris	W.	......	......	......	......	47.2	31.2	22.4	18 30 33.60	....	....	....	....	......
	γ^1 Sagittarii		16.5	34.5	53.0	12.0	30.0	48.8	7.4	18 45 11.74	....	....	....	....	......
	ζ Aquilæ		44.0	1.6	19.0	36.4	54.4	12.0	29.0	18 58 36.63	....	....	....	....	......
	β^1 Sagittarii		43.4	7.8	31.4	56.0	20.0	44.0	7.6	19 11 55.74	....	....	....	....	......
	δ Aquilæ		10.6	27.6	44.8	2.0	19.0	35.5	53.0	19 18 1.79	....	....	....	....	......
	β Cygni		48.5	8.0	27.0	46.4	5.8	24.8	44.0	19 24 46.36	....	....	....	....	......
§22	Moon, 1st L.	W.	16.6	34.4	53.2	11.4	29.6	48.0	6.4	7 10 11.[illegible]	....	....	....	....	......
[illegible]	Moon, 1st L.	W.	26.0	44.4	3.4	21.4	39.8	58.4	16.8	7 57 21.46	....	....	....	....	......
24	λ Sagittarii	W.	34.8	53.6	12.4	31.2	50.0	8.8	29.6	8 28 31.20	....	— 0.66	+ 9 50 10.66	18 18 41.20	41.13
	Moon, 1st L.		59.4	18.6	36.4	54.8	13.4	32.0	50.0	8 44 54.94	....	— 0.48	9 50 13.35	18 35 7.81	......
	ν^1 Sagittarii		55.6	13.6	32.0	50.8	9.2	28.6	46.0	8 54 50.83	....	— 0.59	9 50 14.99	18 45 5.23	5.25
	o Sagittarii		29.2	46.6	......	......	......	......	......	9 4 37.90	+ 45.77	— 0.56	9 50 16.72	18 55 39.83	40.09
	α Aquilæ		10.8	28.0	45.2	2.4	19.6	36.8	53.4	9 53 2.32	....	+ 0.21	9 50 24.55	19 43 27.08	27.05
27	ζ Aquilæ	W.	......	......	0.4	18.0	35.2	52.4	10.2	8 56 35.24	— 17.47	+ 0.35	10 2 11.72	18 58 29.81	29.92
	β^1 Sagittarii		24.2	48.0	12.0	35.6	59.6	23.6	48.6	9 9 35.94	....	— 0.97	10 2 13.90	19 11 48.78	48.88
	δ Aquilæ		49.0	6.4	23.0	40.0	57.2	14.0	30.8	9 15 40.06	....	+ 0.11	10 2 14.90	19 17 55.08	55.01
	β Cygni		25.2	44.8	3.6	22.8	42.0	1.2	20.0	9 22 22.80	....	+ 0.61	10 2 6.09	19 24 39.42	39.78
	h^2 Sagittarii		20.8	39.6	58.4	16.8	35.8	54.4	13.2	9 25 17.00	....	— 0.42	10 2 16.47	19 27 33.05	33.09
	γ Aquilæ		56.4	13.8	30.8	48.0	5.0	22.0	39.6	9 36 47.94	....	+ 0.25	10 2 18.37	19 39 6.57	6.86
‡	β Capricorni	E.	16.8	35.2	58.2	10.4	28.0	45.6	3.2	10 10 10.34	....	— 0.34	10 2 23.85	20 12 33.85	33.68
	π Capricorni		......	......	......	18.4	36.0	54.2	12.0	10 16 45.15	— 27.01	— 0.41	10 2 24.86	20 18 42.59	42.82
	ν Capricorni		9.0	27.4	44.4	2.4	20.8	38.0	56.4	10 29 2.63	....	— 0.41	+ 10 2 26.95	20 31 29.17	29.46

* Resumed sidereal chronometer No. 420. † Instrument adjusted in azimuth. ‡ Instrument reversed. § Mean-time chronometer No. 76.

Longitude of Camp Riley—Continued.

DATE.	OBJECT.	LAMP.	CHRONOMETER TIMES OF TRANSIT. I.	II.	III.	IV.	V.	VI.	VII.	MEAN OF OBS'D WIRES	CORRECTION FOR— Imperfect transit.	Instrument.	Chronometer.	OBSERVED A.R.	TABULAR A.R.
1849.			s.	s.	s.	s.	s.	s.	s.	h. m. s.	s.	s.	h. m. s.	h. m. s.	s.
Sept. 27	ε Aquarii	E.	12.4	30.0	47.2	4.4	21.6	38.8	56.0	10 37 4.34	....	− 0.24	+10 2 28.27	20 39 32 37	[illegible]
	μ Aquarii		12.0	29.6	46.8	4.0	21.6	......	55.4	10 41 58.23	+ 6.38	− 0.60	10 2 29.09	20 44 33.10	32 85
	η Capricorni		25.6	44.0	2.0	20.4	38.4	56.4	14.8	10 53 20.23	....	− 0.40	10 2 30.94	20 55 50.72	50.81
	ν Aquarii		0.8	18.0	35.6	52.8	10.4	27.6	44.8	10 58 52.86	....	− 0.28	10 2 31.85	21 1 24.43	24.33
	ζ Cygni		1.4	20.8	40.4	0.0	19.8	39.2	58.4	11 4 0.00	....	+ 0.53	10 2 32.69	21 6 33.22	33.25
*	Moon, 1st L		40.4	58.4	16.4	34.4	52.4	10.2	28.0	11 8 34.31	....	− 0.21	10 2 33.44	21 11 7.54	......
28	ζ Cygni	W.	3.2	22.4	42.4	2.4	21.6	40.8	0.8	11 0 1.94	....	+ 0.45	+10 6 30.85	21 6 33.24	33.23
	ι Capricorni		27.4	45.0	2.8	20.5	38.4	56.0	14.0	11 7 20.59	....	− 0.25	10 6 32.05	21 13 52.39	[illegible]
†	β Aquarii		14.0	31.6	48.0	5.4	22.4	39.6	......	11 16 56.83	+ 8.55	− 0.09	10 6 33.66	21 23 38.95	38.96
	Moon, 1st L		34.0	52.8	10.8	28.0	46.8	3.6	22.4	11 56 28.34	....	− 0.16	10 6 39.89	22 3 8.07	......
29	ζ Cygni	W.	......	24.8	45.0	3.8	23.6	43.2	2.4	10 56 13.80	− 9.76	+ 0.64	+10 10 28.54	21 6 33.32	33.21
	β Aquarii		16.0	33.0	50.0	......	24.4	41.2	58.0	11 13 7.10	0.00	− 0.12	10 10 31.35	21 23 38.33	38.95
	γ Capricorni		20.0	37.8	55.4	13.6	31.2	49.2	6.8	11 21 13.43	....	− 0.35	10 10 32.68	21 31 45.76	45.71
	δ Capricorni		18.0	36 0	53.6	11.6	29.2	46.8	4.8	11 28 11.43	....	− 0.34	10 10 33.83	21 38 44.92	44.65
	ι Aquarii		49.8	7.6	24.8	42.4	0.0	17.8	35.2	11 47 42.51	....	− 0.29	10 10 37.05	21 58 19.27	19.27
	θ Aquarii		24.2	41.6	58.8	16.0	33.2	50.0	7.6	11 58 15.91	....	− 0.17	10 10 38.78	22 8 54.52	54.42
	γ Aquarii		23.4	40.4	57.6	14.8	31.6	48.4	5.6	12 3 14.54	....	− 0.04	10 10 39.60	22 13 54.10	54.07
	σ Aquarii		8.8	26.0	43.6	1.0	18.0	35.6	53.2	12 12 0.90	....	− 0 23	10 10 41.05	22 22 41.72	41.78
	ζ Pegasi		24.0	41.6	58.8	16.0	33.2	50.4	7.6	12 23 15.80	....	+ 0.20	10 10 42.90	22 33 58.90	58.77
	λ Aquarii		10.8	28.0	45.2	2.4	19.6	36.8	54.0	12 34 2.40	....	− 0.17	10 10 44.68	22 44 46.91	46.84
	α Piscis Australis		36.8	56.4	16.0	35.6	55.6	15.2	35.0	12 38 35.80	....	− 0.66	10 10 45.43	22 49 20.57	20.56
	Moon, 1st L		38.0	55.8	13.6	31.0	48.8	6.4	23.8	12 44 31.06	....	− 0.15	10 10 46.13	22 55 17.04	......
	ψ^3 Aquarii		28.4	45.6	3.0	20.4	37.6	54.8	12.0	13 0 20.26	....	− 0.21	10 10 49.01	23 11 9.06	9.04
†30	λ Aquarii	E.	13.2	30.8	47.8	5.0	22.4	39.6	56.8	12 30 5.09	....	− 0.18	+10 14 42.18	22 44 47.09	46.85
	α Piscis Australis		38.8	58.4	18.4	38.0	58.0	17.6	37.4	12 34 38.09	....	− 0.71	10 14 42.93	22 49 20.31	20.56
	α Pegasi		40.0	58.0	15.6	33 0	50.4	8.0	25.6	12 42 32.94	....	+ 0.31	10 14 44.24	22 57 17.49	17.49
	Moon, 1st L		7.2	24.8	42.0	59.4	17.0	34.0	51.6	13 32 59.43	....	− 0.07	10 14 52.24	23 47 51.60	......
Oct. 4	α Arietis	E.	42.4	0.8	18.8	37.2	55.6	14.0	32.4	15 27 37.31	....	....	....	....	......
	ξ^1 Ceti		4.8	22.0	38.8	56.0	13.2	30.2	47.4	15 33 56.06	....	....	....	....	......
	ξ^2 Ceti		10.8	27.6	44.4	1.6	18.4	36.0	52.8	15 49 1.66	....	....	....	....	......
	783		50.0	......	32.4	......	......	......	......	15 54 11.20	....	....	....	....	......
	γ Ceti		......	......	......	48.8	6.0	23.6	40.4	15 57 14.70	....	....	....	....	......
	832		25.2	48.0	10.4	32.4	54.8	17.6	39.6	16 3 32.57	....	....	....	....	......
	π Arietis		49.6	6.8	24.0	41.8	59.6	17.8	35.2	16 9 42.11	....	....	....	....	......
‡	α Ceti		......	38.0	......	......	......	......	......	38.00	....	....	....	....	......
5	γ Aquilæ	E.	......	30.8	48.0	5.2	22.4	39.6	56.4	9 5 13.73	....	....	....	....	......
	α Aquilæ		32.8	50.0	7.6	24.8	42.0	......	16.0	9 9 18.87	....	....	....	....	......
	ζ^1 Sagittarii		29.2	46.8	4.4	21.6	39.6	57.2	14.8	9 15 21.94	....	....	....	....	......
§8	α Cygni		2.8	26.8	50.4	14.4	39.2	2.4	26.0	9 50 14.57	....	....	....	....	......
23	γ Aquilæ	E.	50.0	7.6	24.4	41.6	59.2	16.4	33.6	7 53 41.83	....	− 0.17	+11 45 24.82	19 39 6.48	6.38
	α Aquilæ		9.6	26.4	44.0	0.8	18.0	35.6	52.6	7 58 1.00	....	− 0.14	11 45 25.53	19 43 26.39	26.53
	ζ^1 Sagittarii		......	22.8	40.4	58.0	16.0	33.4	50.8	8 4 6.90	− 8.84	+ 0.27	11 45 26.51	19 49 24.86	24.88
	Moon, 1st L		54.0	12.4	30.8	49.0	7.6	25.6	44.6	8 11 49.14	....	+ 0.30	11 45 27.80	19 57 17.24	......
	α^2 Capricorni		20.0	37.6	54.4	12.0	29.6	47.0	4.4	8 24 12.14	....	+ 0 22	11 45 29.67	20 9 42.03	42.23
	β Capricorni		9.8	27.4	45.2	2.6	20.4	38.0	55.6	8 27 2 71	....	+ 0.25	11 45 30.31	20 12 33.27	33.34
	π Capricorni		16.8	34.8	52.8	10.8	28.8	46.8	4.4	8 33 10.74	....	+ 0.32	11 45 31.31	20 18 42.37	42.38
	ν Capricorni		1.6	19.6	37.2	55.0	13.2	31.2	49.2	8 45 55.28	....	+ 0.32	11 45 33.40	20 31 29.00	29.03
†25	μ Aquarii	W.	7.2	24.8	42.4	59 2	16.6	33.6	50.8	8 50 59.23	....	+ 0.24	+11 53 33.20	20 44 32.67	32.42
	η Capricorni		20.4	38.8	57.0	14.8	33.2	51.2	9.2	9 2 14.94	....	+ 0.53	11 53 35.04	20 55 50.51	50.36
	ν Aquarii		56.6	13.2	30.0	48.0	5.4	22.4	39.6	9 7 47.80	....	+ 0.30	11 53 35.95	21 1 23.05	23.91
	29 Capricorni		55.0	12.8	30.4	48.0	5.8	23.2	40.8	9 13 48.00	....	+ 0.31	11 53 36.92	21 7 [illegible]	[illegible]
	ι Capricorni		20.0	38.0	55.8	13.8	31.6	49.4	7.2	9 20 13.69	....	+ 0.45	11 53 37.96	21 13 52.10	52.06
	β Aquarii		7.3	24.4	41.2	58.8	16.0	32.8	......	9 29 50.08	+ 8.55	+ 0 16	11 53 39.54	[illegible]	[illegible]
	γ Capricorni		10.4	28 0	46.0	4.0	22.0	39.6	57 2	9 38 3.90	....	+ 0.45	11 53 40.85	21 31 45.20	45.35
	Moon, 1st L		11.0	29.2	47.2	5.2	22.8	40.4	58.8	9 46 4.95	....	+ 0.33	11 53 42.23	21 39 47.51	......
	ι Aquarii		40.6	58.0	15.6	33.2	50.8	8.4	26.0	10 4 33.14	....	+ 0.37	+11 53 45.19	21 58 18.70	18.95

* Interrupted by dense clouds. † Instrument reversed. ‡ Interrupted by clouds. § Sky obscured by dense clouds.

Longitude of Camp Riley—Continued.

Date.	[illegible]	Lamp.	Chronometer times of transit. I.	II.	III.	IV.	V.	VI.	VII.	Mean of obs'd wires.	Correction for— Imperfect transits.	Instrument.	Chronometer.	Observed A.R.	Tabular A.R.
1849.			*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h. m. s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*s.*
Oct. 28	μ Aquarii........	W.	11.2	28.4	46.0	2.8	20.4	37.2	54.4	8 39 2.91	....	+ 0.24	+12 5 29.70	20 44 32.85	[illegible]
	η Capricorni......		24.4	[illegible]	0.8	[illegible]	37.2	54.8	13.2	8 50 18.86	....	+ 0.53	[illegible] 5 31.55	20 55 50.94	50.31
	ξ Cygni...........		1.6	21.2	40.8	0.4	20.0	39.6	59.2	9 1 0.40	....	— 0.81	12 5 33.28	21 6 32.87	[illegible]
	[illegible] Piscium........		24.4	41.6	58.4	15.6	32.4	49.2	6.4	11 34 15.43	....	+ 0.09	12 5 58.24	23 40 13.76	13.51
	27 Piscium		8.4	[illegible]	[illegible]	[illegible]	16.4	33.6	50.4	11 44 50.34	....	+ 0.11	12 5 59.98	23 50 59.43	[illegible]
	α Andromedæ		......	......	18.8	38.4	57.6	16.8	36.0	11 54 57.52	— 19.28	— 0 77	12 6 1.54	39.01	38.80
	γ Pegasi...........		36.4	53.6	11.6	[illegible]	46.4	4.0	21.6	11 59 28.97	....	— 0.37	12 6 2.33	5 30.93	[illegible]
	Moon, 1st L....		26.8	44.0	2.0	19.2	36.8	54.4	11.6	12 9 19.26	....	+ 0.03	12 6 3.95	15 23.24	......
	[illegible] Ceti............		......	17.2	34.4	51.2	8.0	25.2	42.0	[illegible]	....	+ 0.02	12 6 4.52	[illegible]	55.76
	13 Ceti		34.0	51.2	8.0	[illegible]	42.8	59.6	16.4	12 21 25.31	....	+ 0.11	12 6 5.91	27 31.33	31.45
	δ Piscium		54.4	11.6	[illegible]	46.0	3.2	20.4	37.6	12 34 46.00	....	— 0.17	12 6 8.09	40 53.92	[illegible]
	[illegible] Ceti............		20.2	37.2	54.4	11.6	28.4	45.2	2.4	12 39 11.34	....	+ 0.05	12 6 8.79	45 20.18	[illegible]
[illegible]	δ Piscium	W.	57.2	14.2	31.6	48.8	5.6	23.2	39.8	12 30 48.63	....	— 0.17	+12 10 5.60	40 54.06	54.21
*	[illegible] Ceti...........	E.	22.8	39.6	57.0	14 4	31.2	48.0	4.8	12 35 14.00	....	+ .05	12 10 6.33	45 20.38	[illegible]
	ε Piscium		10.6	27.6	45.0	2.0	19.2	36.0	53.2	12 45 2.00	....	+ 0.18	12 10 7.94	55 10.12	[illegible]
	Moon, 1st L....		35.0	52.4	9 2	26.8	44.4	2.4	19.2	12 59 27.06	....	— 0 09	12 10 10.31	1 9 37.28	......
	θ¹ Ceti..........		28.0	45.4	2.4	19.6	36.8	54.4	11.6	13 6 19.74	....	+ 0.23	12 10 11.44	1 16 31.41	31.57
	μ Piscium		16.4	33.6	50.4	7.6	24.8	41.8	58.8	13 12 7.63	....	— 0.13	12 10 12.39	1 22 19.89	19.71
	ν Piscium		32.4	49.8	6.4	[illegible]	40.8	58.0	14.8	13 23 23.69	....	— 0.12	12 10 14.24	1 33 37.81	37.80
	ο Piscium		22.4	40.0	57.2	14.4	31.6	48.8	6.0	13 27 14.34	....	— 0.21	12 10 14.87	1 37 29.00	28.77
Nov. 1	ξ Tauri...........	W.	45.2	1.6	19.0	36.0	53.6	11.2	28.4	14 56 36.43	....	— 0.23	+12 22 26.82	3 19 3.02	[illegible]
	e Tauri...........		41.2	[illegible]	15.6	33.2	50.4	8.0	25.2	15 17 33.20	....	— 0.27	12 22 30.26	3 40 3.19	[illegible]
	λ Tauri...........		58.0	16.0	[illegible]	50.4	8.0	25.2	42.4	15 29 50.46	....	— 0.31	12 22 32.28	3 52 22.43	[illegible]
	Moon, 2d L.....		28.8	47.2	5.2	23.6	41.6	59.6	17.8	15 46 23.40	....	— 0.41	12 22 35.00	4 8 57.99	......
	ε Tauri...........		21.2	39.4	57.6	15.6	33.4	51.2	9.6	15 57 15.43	....	— 0.49	12 22 36.78	4 19 51.72	51.82
	α Tauri...........		48.4	6.0	[illegible]	41.6	59.2	17.0	34.4	16 4 41.49	....	— 0.42	12 22 38.01	4 27 19.08	[illegible]
2	ε Tauri...........	W.	22.8	40.8	59.2	17.2	34.8	52.8	10.8	15 53 16.92	....	— 0.49	+12 26 35.87	4 19 52.30	51.83
	α Tauri...........		50.0	7.8	24.8	42.8	0.2	18.0	35.8	16 0 42.77	....	— 0.42	12 26 37.09	4 27 19.44	19.11
	ο¹ Orionis.........		30.8	48.4	6.0	23.6	41.2	58.4	16.0	16 17 23.50	....	— 0.36	12 26 39.83	4 44 2.97	[illegible]
	ι Tauri...........		32.0	50.6	8.8	[illegible]	45.2	3.2	21.6	16 27 26.89	....	— 0.56	12 26 41.48	4 54 7.81	7.92
	11 Orionis		......	......	[illegible]	18.4	36.2	53.4	11.0	16 29 35.88	— 17.59	— 0.39	42 26 41.79	4 55 59.69	60.03
	β Orionis.........		44.0	1.4	18.4	35.6	52.8	10.0	27.2	16 40 35.63	....	+ 0.21	12 26 43.65	[illegible]	[illegible]
†	Moon, 2d L.....		58.4	16.8	[illegible]	53.6	12.0	30.4	48.8	16 45 53.60	....	— 0.47	12 26 44.54	5 12 37.67	......
[illegible]	68 Geminorum.....	E.	9.2	27.2	44.8	2.2	20.0	38.0	55.2	18 46 2.37	....	0.00	+12 39 5.05	7 25 1.94	1.90
	α Canis Minoris..		34.0	51.6	8.4	[illegible]	42.8	58.8	16.8	18 52 25.43	....	0.00	[illegible] 0.06	7 31 26.06	[illegible]
	β Geminorum		......	26.8	46.0	5.2	24.6	44.0	3.4	18 57 15.00	— 9.67	0.00	12 39 1.39	7 36 6.72	6.90
	15 Argus		7.8	26.4	45.2	3.8	22.4	40.4	59.4	19 22 3.63	....	0.00	12 39 5.49	8 1 9.12	8.99
	d¹ Cancri		43.4	1.6	19.6	37.4	55.6	13.4	31.2	19 35 37.46	....	0.00	[illegible] 7.72	8 14 45.18	45.09
	Moon, 2d L.....		50.8	9.2	27.2	45.2	3.6	22.0	40.2	19 43 45.46	....	0.00	12 39 9.06	[illegible]	......
	δ Cancri		2.8	21.2	39.2	56.8	14.8	33.2	50.8	19 56 56.97	....	0.00	12 39 11.22	8 36 8.19	8.13
	ε Hydræ..........		45.8	2.8	19.8	37.2	54.4	11.6	28.4	19 59 37.14	....	0.00	12 39 11.66	8 38 48.80	48.73
•	α Cancri..........		9.6	27.2	44.4	2.0	19.2	36.8	54.0	20 11 1.90	....	0.00	+12 39 13.54	8 50 15.44	15.52
6	δ Cancri..........	E.	2.4	20.4	38.4	56.4	14.0	32.4	50.4	....	....	....	....	....	......
	α Cancri..........		[illegible]	27.4	44.0	1.2	18.8	36.4	53.2	....	....	....	....	....	......
	α Hydræ..........		1.2	18.8	35.6	[illegible]	10.0	27.2	44.4	....	....	....	....	....	......
29	20 Piscium........	E.	[illegible]	20.0	36.8	54.0	10.8	28.0	45.2	....	....	....	....	....	......
	α Andromedæ		18.0	37.6	[illegible]	16.0	35.2	55.2	13.6	....	....	....	....	....	......
	γ Pegasi..........		14.8	[illegible]	50.0	7.2	25.2	42.8	0.4	....	....	....	....	....	......
	19 Ceti............		[illegible]	56.0	13.2	30.0	47.2	4.0	20.8	....	....	....	....	....	......
	[illegible] Ceti............		12.8	30.0	47.2	4.0	21.2	38.4	[illegible]	....	....	....	....	....	......
	β Ceti............		40.0	57.6	16.0	33.6	51.6	9.6	27.6	....	....	....	....	....	......

* Instrument reversed. † Wire VI indistinct.

From the "Greenwich Observations" for 1849 we obtain the following observed corrections of the AR. of the moon's bright limb:

			s.				s.
July	27	1st L.	—0.51	Sept.	22	1st L.	—0.68
	28		.55		25		.15
	29		.48		26		.22
	30		.48		30		.56
	31		.26	Oct.	2	2d L.	.67
Aug.	1		.44		4		.65
	3		.18		5		.47
	3	2d L.	.73		8		.32
	4		.38		9		.67
	6		.38				
	8		.54	Oct.	28	1st L.	.60
	11		.62		29		.67
					31		.73
Aug.	23	1st L.	—1.22	Nov.	1	2d L.	.50
	24		.68		4		.60
	29		.46		5		.74
	31		.47				
Sept.	5	2d L.	.22				
	8		.41				
	9		.51				

Longitude of Camp Riley by corresponding observations.

	h. m. s.		h. m. s.		h. m. s.
July 27	7 48 37.98	Aug. 3	7 48 51.51	Oct. 28	7 48 24.48
28	23.51	29	39.97	29	15.13
29	7.45	Sept. 5	6.99	Nov. 1	13.41
30	37.60	30	18.27	5	25.37
31	39.29				

		h. m. s.
Mean		7 48 24.70
Probable error of result	=	± 2.32
Probable error of single observation	=	± 8.05

The following have been adopted as corrections for the respective lunations:

	s.		s.
July 27 to August	— 0.47	September 22 to October	— 0.48
August 23 to September	— 0.54	October 28 to November	— 0.63

Applying these corrections to the computed AR. of the moon's limb for each date of observation, and comparing with the observed AR., we obtain:

	h. m. s.		h. m. s.		h. m. s.
July 27	7 48 36.81	Aug. 28	7 48 21.77	Sept. 30	7 48 17.78
28	20.90	29	41.89	Oct. 23	34.80
29	6.88	Sept. 3	9.77	25	22.50
30	37.32	4	18.54	28	25.02
31	45.08	5	15.12	29	14.09
Aug. 2	29.28	24	41.90	Nov. 1	16.17
3	39.60	27	34.61	2	18.00
26	23.07	28	22.98	5	22.75
27	36.91	29	21.85		

	h. m. s.
Mean	7 48 25.98
Longitude of Camp Riley, computed in the field from the predicted place of the moon in the Greenwich ephemeris for 1849	7 48 13.1
Difference	12.88

	s.
Probable error of a single observation	± 7.21
Probable error of result	± 1.44

II.—*Longitude of junction of the Gila and Colorado: By Lieut. A. W. Whipple.*

DATE.	OBJECT.	LAMP.	CHRONOMETER TIMES OF TRANSIT. I.	II.	III.	IV.	V.	VI.	VII.	MEAN OF OBS'D WIRES	CORRECTIONS FOR— Imperfect transits.	Instrument.	Chronometer.	OBSERVED A.R.	TABULAR A.R.
1849.			*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h. m. s.*	*s.*	*s.*	*m. s.*	*h. m. s.*	*s.*
Oct. 3	α Arietis	E.	5.5	24.5	44.5	3.0	22.0	40.0	59.5	1 58 2.71	....	− 0.56	+ 0 41.83	1 58 43.98	43.62
	64 Ceti		52.0	9.5	27.0	45.0	3.0	20.5	38.0	2 2 45.00	....	0.15	41.83	2 3 26.68	26.82
	Moon, 2d L.		52.0	10.5	......	......	5.0	23.5	42.0	2 33 50.60	− 3.64	0.23	41.81	2 34 28.54	......
	α Ceti		52.0	10.0	27.5	44.5	2.0	20.0	37.5	2 53 44.79	....	0.08	41.80	2 54 26.51	26.33
	δ Arietis		25.5	44.5	3.5	21.5	40.5	59.5	17.5	3 2 21.79	....	0.46	41.79	3 3 3.12	3.33
	α Persei		37.0	4.0	31.0	57.5	24.5	52.0	19.0	3 12 57.86	....	1.56	41.78	3 13 38.09	38.40
	ξ Tauri		27.5	45.0	3.5	21.0	38.5	56.5	14.5	3 18 20.93	....	0.22	41.76	3 19 2.47	2.32
4	μ Ceti		18.0	35.5	53.5	11.5	29.5	46.5	5.0	2 36 11.36	....	− 0.17	+ 0 39.61	2 36 50.39	50.11
	α Ceti		54.5	13.5	29.5	46.5	5.0	22.5	40.0	2 53 47.36	....	0.06	39.09	2 54 26.39	26.35
	δ Arietis		29.0	47 5	6.0	25.0	43.5	2.0	20.5	3 2 24.79	....	0.36	39.08	3 3 3.51	3.34
	α Persei		......	7.0	34.0	0.0	27.0	54.5	22 0	3 13 14.08	− 13.50	1.19	39.07	3 13 38.46	38.43
	ξ Tauri		30.0	48.0	5.5	23.0	41.0	59.0	17.0	3 18 23.34	....	0.17	39.06	3 19 2.23	2.34
	ε Tauri		40.0	58.0	16.5	34.0	51.5	9.5	28.0	3 21 33.93	....	0.20	39.05	3 22 12.78	12.66
	Moon, 2d L.		30.0	49.0	7.5	26.0	44.5	3.0	21.0	3 32 25.86	....	0.25	39.04	3 33 4.65	......
	e Tauri		......	......	......	......	41.0	59.5	17.5	3 39 59.33	− 35.74	0.19	39.03	3 40 2.43	2.60
	λ Tauri		49.5	7.0	25.0	43.0	1.0	19.0	37.0	3 51 43.07	....	0.22	39.01	3 52 21.86	22.04
5	α Arietis	E.	45.0	4.5	23.5	42.0	1.5	20.5	39.5	1 46 42.36	....	− 0.67	+ 12 2.06	1 58 43.75	43.65
	ξ^1 Ceti		8.5	26.5	44.0	1.5	19.5	37.5	55.0	1 53 1.79	....	0.51	2.06	2 5 3.34	3.12
	α Ceti		31-5	49.5	7.0	24.5	42.5	59.5	17.5	2 42 24.57	....	0.48	2.06	2 54 26.15	26.37
	α Persei	W.	15.5	42.0	9.5	36.5	2.5	29.5	56.5	3 1 36.00	....	+ 0.18	2.06	3 13 38.24	38.46
	ξ Tauri		6.0	24.0	42.0	59.5	18.0	35.5	53.5	3 6 59.79	....	0.38	2.06	3 19 2.23	2.36
	e Tauri		......	24.5	42.5	0.5	18.0	35.5	53.5	3 28 9.08	− 8.94	0.37	2.06	3 40 2.57	2.63
	λ Tauri		26.0	43.5	1.5	20.0	37.5	55.5	13.5	3 40 19.64	....	0.37	2.06	3 52 22.07	22.07
	α Tauri		21.5	39.5	57.5	16.5	34.5	52.5	11.5	4 15 16.21	....	0.35	2.06	4 27 18.62	18.47
	Moon, 2d L.		40.0	59.0	17.5	36.5	55.5	14.5	33.5	4 21 36.64	....	0.35	2.06	4 33 39.05	......
	o^1 Orionis		......	23.5	42.0	0.0	18.0	36.0	54.5	4 32 9.00	− 9.05	0.36	2.06	4 44 2.37	2.36
	ι Tauri		8.5	27.5	46.5	5.0	23.5	42.5	1.5	4 42 5.00	....	0.32	2.06	4 54 7.38	7.20
6	γ Tauri	W.	48.8	7.2	25.6	43.6	1.6	19.6	28.0	4 10 43.49	....	0.00	+ 31.67	4 11 15.16	15.15
	α Tauri		52.0	10.8	28.8	46.8	5.2	23.6	41.6	4 26 46.97	....	0.00	31.64	4 27 18.61	18.50
	o^1 Orionis		36.4	54.8	13.6	31.2	48.8	7 2	25.2	4 43 31.03	....	0.00	31.61	4 44 2.64	2.39
	ι Tauri		38.8	58.0	16.8	35.6	54.4	13.6	32.0	4 53 35.60	....	0.00	31.58	4 54 7.18	7.22
	α Aurigæ		49.6	14.8	39.6	5.2	30.0	54.8	20.4	5 5 4.91	....	0.00	31.55	5 5 36.46	36.04
	ο Tauri		8.8	25.4	46.4	5.2	24.0	43.2	2.4	5 18 5.06	....	0.00	31.52	5 18 36.58	36.68
	δ Orionis		55.6	11.2	30.4	48.0	5.6	23.2	40.8	5 23 48.83	....	0.00	31.50	5 24 20.33	19.95
	ζ Tauri		10.8	30.8	49.6	8.4	26.8	46.0	4.8	5 28 8.17	....	0.00	31.48	5 28 39.65	37.97
	Moon, 2d L.		12.0	30.8	49.6	8.8	27.0	46.4	5.0	5 35 8.66	....	0.00	31.45	5 35 40.05	......
	α Orionis		......	......	......	......	48.0	6.0	23.6	5 47 5.87	− 35.40	0.00	31.43	5 47 1.90	2.14
	η Geminorum		20.0	38.4	57.6	16.4	35.6	54.4	14.0	6 5 16.63	....	0.00	31.49	6 5 48.02	48.31
	μ Geminorum		23.2	42.4	1.2	20.4	39.2	58 4	17.6	6 13 20.34	....	0.00	31.37	6 13 51.71	51.83
7	α Aurigæ	W.	......	......	......	......	32.0	58.0	23 2	5 5 37.73	− 50.39	− 0.90	+ 29.74	5 5 36.18	36.08
	δ Orionis		......	......	......	50.0	8.0	25.6	43.2	5 24 16.70	− 26.34	+ 0.01	29.71	5 24 20.08	19.97
	ζ Tauri		12.8	33.2	52.0	10.8	30.4	......	7.6	5 28 4.47	+ 6.26	− 0.34	29.70	5 28 40.09	40.00
	α Orionis		39.6	......	14.2	32.8	50.4	8.0	26.0	5 46 38.50	− 5.91	0.11	29.68	5 47 2.16	2.17
	η Geminorum		21.6	40.4	0.4	19.6	38 0	56.8	16.4	6 5 19.03	....	0.36	29.66	6 5 48.33	48.34
	μ Geminorum		26.0	44.0	4.0	23.2	41.6	0.8	20.0	6 13 22.80	....	0.37	29.65	6 13 52.08	51.86
	Moon, 2d L.		44.4	4.0	23.2	......	......	......	39.2	6 37 27.70	+ 14.26	0.30	29.63	6 38 11.29	.....
	ζ Geminorum		......	......	23.2	42.0	0.8	19.6	......	6 54 51.40	− 9.39	0.33	29.61	6 35 11.29	11.67
23	α Aquilæ	W.	28.8	46.8	4.8	22.4	39.6	57.6	15.6	19 43 22.23	....	− 4.34	+ 8.79	19 43 26.68	26.54
	β Aquilæ		56.8	......	32.0	49.6	7.2	25.2	42.0	19 47 55.47	− 5.90	− 3.08	8.79	19 47 55.28	55.38
	Moon, 1st L.		......	......	......	36.0	55.2	14.0	33.2	19 57 4.60	− 28.39	+ 9.76	8.79	19 56 54.76	......
	α^2 Capricorni		......	50.4	9.2	26.0	43.6	2.8	20.8	20 9 35.60	− 9.02	+ 6.72	8.79	20 9 42.09	42.24
	α Cygni		24.8	49.2	14.8	38.8	3.2	28.0	53.2	20 36 38.86	....	− 28.85	8.79	20 36 18.80	18.80
	η Capricorni		24.4	53.2	12.0	31.2	49.6	8.0	27.2	20 55 30.80	....	+ 10.85	8.79	20 55 50.44	50.39
	61^1 Cygni		17.6	40.0	1.6	23.6	46.0	9.2	32.0	21 0 24.29	....	− 2.75	8.79	21 0 10.33	10.13
	ζ Cygni		40.0	0.0	20.4	40.4	0.8	20.4	40.8	21 6 40.40	....	− 16.55	+ 8.79	21 6 32.64	32.77

Longitude of junction of the Gila and Colorado—Continued.

Date.	Object.	Lamp.	Chronometer times of transit. I.	II.	III.	IV.	V.	VI.	VII.	Mean of obs'd wires.	Corrections for— Imperfect transits.	Instrument.	Chronometer.	Observed A.R.	Tabular A.R.
1849.			s.	s.	s.	s.	s.	s.	s.	h. m. s.	m. s.	m. s.	s.	h. m. s.	s.
Oct. 23	α Cephei........	W.	54.4	31.6	8.8	46.0	23.2	8.0	38.0	21 15 47.14	....	− 54.62	+ 8.79	21 15 1.31	0.63
	β Aquarii		33.2	51.2	9.2	26.8	44.0	1.6	20.0	21 23 26.57	....	+ 3.18	8.79	21 23 38.54	38.62
	β Cephei		21.2	12.0	3.2	54.4	45.2	36.0	28.0	21 27 54.29	....	−1 19.57	8.79	21 26 43.51	44.30
	ε Pegasi		51.6	8.8	26 8	44.4	2.0	19.6	......	21 36 35.53	+ 8.91	− 4.70	8.79	21 36 48.53	48.51
	α Aquarii.........		2.0	19.6	37.2	54.8	12.0	29.6	47.2	21 57 54.63	....	+ 0.54	8.79	21 58 3.96	3.96
	ζ Pegasi		......	20.0	38.0	55.2	12.8	31.2	48.8	22 34 4.33	− 8.92	− 5.16	8.79	22 33 59.04	58.56
24	π Capricorni......	W.	......	17.2	35.6	54.0	12.0	30.8	49.6	20 19 3.20	− 9.27	+ 0.48	− 12.15	20 18 42.26	42.36
*	Moon, 1st L....		......	50.0	8.8	27.6	46.0	5.2	24.0	20 48 36.93	− 9.34	0.42	12.15	20 48 15.86	......
	η Capricorni......		6.0	24.4	43.2	2.4	20.6	39.2	58.4	20 56 2.03	....	0.53	12.15	20 55 50.41	50.41
	29 Capricorni......		42.8	0.8	19.2	37.2	55.2	14.0	32.0	21 7 37.31	....	0.40	12.15	21 7 25.56	25.24
	ι Capricorni......		9.0	27.2	45.6	4.2	20.6	41.2	59.2	21 14 3.86	....	0.44	12.15	21 13 52.15	52.08
	β Aquarii.........		......	......	......	......	8.0	25.6	43.6	21 24 25.73	− 35.32	0.15	12.15	21 23 38.41	38.60
	ε Pegasi		7.2	25.2	43.2	0.8	18.4	36.4	54.0	21 37 0.74	....	− 0.23	12.15	21 36 48.36	48.49
	ζ Pegasi..........		17.6	35.2	53.2	10.8	28 8	46.4	4.8	22 34 10.97	....	− 0.25	12.15	22 33 58.57	58.54
25	η Capricorni......	E.	22.0	40.8	59.6	18.4	36.8	56.0	14.4	20 56 18.29	....	....	− 27.80	20 55 50.49	50.36
	61 Cygni		32 0	54.4	16.8	......	0.8	23.2	40.8	21 0 38.00	− 0.01	0.00	27.80	21 0 10.19	10.09
	29 Capricorni......		58.4	17.2	35.2	53.2	12.0	29.6	48.0	21 7 53.37	....	0.00	27.80	21 7 25.57	25.23
†	ι Capricorni......		24.8	45.2	1.6	20.0	38.4	57.2	15.6	21 14 20.11	....	0.00	27.80	21 13 52.31	52.06
	β Aquarii.........		13.6	31.2	49.2	6.4	24.0	42.0	59.6	21 24 6.57	....	0.00	27.80	21 24 38.77	38.58
	Moon, 1st L....		......	16.8	35.2	53.6	12.2	31.2	49.2	21 40 3.03	− 9.93	0.00	27.80	21 39 25.30	......
	ι Aquarii		52.0	10.4	28.8	46.8	4.4	23.2	41.2	21 58 46.69	....	0.00	27.80	21 58 18.89	18.95
‡	σ Aquarii.........		15.2	32.8	50.0	8.8	26.8	44.6	2.4	22 23 8 66	....	0.00	27.80	22 22 40.86	41.52
	ζ Pegasi..........		32.8	50.8	8.4	26.4	44.0	2.2	20.0	22 34 26.37	....	0.00	27.80	22 33 58.57	58.53
	λ Aquarii..		20.8	38.8	56.4	14.4	32 0	49.6	7.6	22 45 14.23	....	0.00	27.80	22 44 46.43	46.62
	α Piscis Australis.		46.8	7.2	28.0	48.0	8.8	28.4	48.8	22 49 48.00	....	0.00	27.80	22 49 20.20	20.31
26	λ Ursæ Minoris...	W.	......	......	......	52.8	33.4	21.4	29.6	20 36 4.30	−22 17.45	+ 22.08	− 29.86	20 13 39.07	34.04
	29 Capricorni......		0.4	18.4	36.8	55.2	13.2	31.2	50.0	21 7 56.03	....	− 0.12	29.86	21 17 25.05	25.21
	ι Capricorni......		26.8	......	3.6	22.0	39.6	58.6	17.4	21 14 28.00	− 6.15	− 0.14	29.86	21 13 51.85	52.05
	β Cephei		......	......	22.4	13.6	4.0	55.6	46.8	21 28 4.48	51.15	+ 1.19	29.86	21 26 44.66	44.13
	γ Capricorni......		20.0	38.2	57.2	15.4	33.2	52.0	10.8	21 32 15.26	....	− 0.14	29.86	21 31 45.26	45.33
	δ Capricorni......		19.2	37.6	55.6	14.8	32.8	50.8	9.6	21 39 14.34	....	− 0.13	29 86	21 38 44.35	44.27
	ι Aquarii		54.4	12.8	30.8	48.8	6.8	25.2	43.6	22 58 48.91	....	− 0.13	29.86	21 58 18.92	18.94
	σ Aquarii.........		18.0	35.6	53.6	12.0	29.6	47.2	5.6	22 23 11.66	....	− 0.09	29.86	22 22 41.71	41.45
	Moon, 1st L....		16.2	34.0	52.8	18.8	28.8	47.2	5.6	22 31 10.77	....	− 0.08	29.86	22 30 40.83	......
	λ Aquarii.........		......	41.2	58.8	16.8	34.4	52.0	10.0	22 45 25.53	− 8.88	− 0.06	29.86	22 44 46.73	46.61
	α Ursæ Maj., S. P.		58.4	36.8	15.4	52.8	30.8	9.2	47.2	22 54 52.94	....	− 0.84	29.86	22 54 22.24	21.60
27	λ Ursæ Minoris...	E.	......	......	......	12.4	52.0	59.2	58.4	20 36 30.50	−22 18.00	− 7.41	− 33.82	20 13 31.27	32.80
	29 Capricorni......		4.0	22.6	40.8	58.8	17.2	35.2	53.6	21 7 58.89	....	+ 0.04	33.90	21 7 24.98	25.20
	ι Capricorni......		30.4	49.2	7.6	26.0	44.4	2.8	21.2	21 14 25.94	....	+ 0.04	33.97	21 14 52.01	52.03
	β Cephei..........		......	......	27.2	18.4	9.2	0.8	52.0	21 28 9.52	− 51.14	− 0.40	34.01	21 26 43.97	44.07
	ι Aquarii.........		58.8	16.8	34.8	52 8	10.8	28.8	46.8	21 58 52.80	....	+ 0.04	34.09	21 58 18.75	18.92
	σ Aquarii.........		21.6	40.0	57.6	15.6	33.6	51.6	9.2	22 23 15.60	....	+ 0.03	34.14	22 22 41.49	41.43
	λ Aquarii.........		27.2	42.2	3.2	20.8	38.4	56.0	14.0	22 45 20.69	....	+ 0.02	34.19	22 44 46.52	46.60
	α Piscis Australis.		53.6	14.0	34.4	54.8	15.2	35.6	55.6	22 49 54.74	....	+ 0.08	34.20	22 49 20.62	20.28
	Moon, 1st L....		2.0	20.0	38.0	56.0	14.0	32.0	50.0	23 22 56.00	....	+ 0.01	34.29	23 22 21.72	......
	20 Piscium		55.6	12.8	30.4	47.6	5.6	23.2	40.8	23 40 48.00	....	+ 0.01	34.34	23 40 13.67	13.52
	27 Piscium		40.8	58.0	16.4	33.6	51.2	8.8	26.4	23 51 33.60	....	+ 0.01	34.37	23 50 59.24	59.44
	β Ceti.............		42.0	0.8	19.2	37.6	56.2	15.2	33.6	0 36 37.80	....	+ 0.05	34.48	0 36 3.37	3.24
	Polaris		44.4	9.2	31.2	40.8	.....	......	......	0 49 46.40	+16 55.02	− 5.83	34.55	0 5 61.04	59.55
28	29 Capricorni.....	E.	6.8	24.8	42.8	0.8	18.8	37.6	56.0	21 8 1.09	....	− 0.08	− 36.08	21 7 24.93	25.19
	β Aquarii....		22.0	39.6	57.2	14.8	32.4	50.0	8.0	21 24 14.86	....	− 0.03	36.14	21 23 38.69	38.54
	β Cephei..........		......	36.4	29.6	20.4	10.8	2.0	53.6	21 27 45.47	− 25.56	+ 0.81	36.15	21 26 44.57	44.01
	δ Capricorni......		15.6	44.0	2.2	20.4	38.8	57.2	15.6	21 39 20.54	....	− 0.09	36.19	21 38 44.26	44.24
	σ Aquarii.........		24.4	42.4	0.0	18.0	36.0	54.0	12.0	22 23 18.11	....	− 0.06	36.37	22 22 41.68	41.42
	λ Aquarii		......	47.6	7.4	23.2	40.4	58.4	16.4	22 45 32.23	− 8.88	− 0.04	36.44	22 44 46.87	46.59
	α Ursæ Minoris...		4.4	42.8	21.2	58.8	36.0	15.2	52.4	22 54 58.69	....	− 0.57	36.48	22 54 21.64	21.66
	γ Cephei		4.8	21.2	38.0	......	......	28.4	......	23 32 38.10	+1 16.95	+ 1.26	− 36.61	23 33 19.70	19 30

* Wire IV recorded 23.6s. † Wire IV recorded 51.2s. ‡ Wire VI recorded 40.6s.

Longitude of junction of the Gila and Colorado—Continued.

DATE.	OBJECT.	LAMP.	CHRONOMETER TIMES OF TRANSIT. I.	II.	III.	IV.	V.	VI.	VII.	MEAN OF OBS'D WIRES	CORRECTIONS FOR— Imperfect transits.	Instrument.	Chronometer.	[illegible] A.R.	TABULAR A.R.
1849.			s.	s.	s.	s.	s.	s.	s.	h. m. s.	m. s.	s.	s.	h. m. s.	[illegible]
Oct. 28	20 Piscium	E.	57.2	14.8	32.8	50.0	7.2	25.0	43.2	23 40 50.03	....	— 0.02	— 36.64	23 40 13.37	13.51
	27 Piscium		43.2	0.8	18.4	36.0	53.6	11.6	29.2	23 51 36 11	....	— 0.02	36.68	23 50 59.41	59.42
	Moon, 1st L.		42.8	1.2	20.0	38.0	56.0	14.0	30.2	0 15 37.71	....	— 0.01	36.76	0 15 0.94	....
	β Ceti		44.4	2.8	21.6	40.4	58.8	17.2	36.0	0 36 40.17	....	— 0.10	36.84	0 36 3.23	3.24
	20 Ceti		4.8	22.0	40.8	57.2	14 8	32.0	50.0	0 45 57.37	....	— 0.01	36.87	0 45 20.49	20.56
	Polaris		31.6	51.2	11.2	......	......	......	......	0 43 51.33	+22 33.44	+ 11.41	36.94	1 5 59.24	59.38
	θ^1 Ceti		15.2	32.8	50.8	8.4	26.4	44.0	2.0	1 17 8.51	....	— 0.05	36.98	1 16 31.48	31.57
29	α Capricorni	W.	3.2	20.3	39.2	56.8	15.9	29.6	......	20 9 47.50	+ 9.02	+ 0.14	— 38.74	20 9 17.92	18.26
	α^2 Capricorni		27.2	45.8	3.4	21.2	39 3	......	......	20 18 3.38	+ 18.04	+ 0.14	38.75	20 9 42.81	42.13
	π Capricorni		26.0	44.4	2.8	21.2	40.0	58.0	17.2	20 19 21.37	....	+ 0.21	38.77	20 18 42.81	42.28
	α Cephei		48.8	26.0	3.2	40.8	17.6	55.6	33.2	21 15 40.74	....	— 1.14	38.87	21 15 0.73	0.38
	β Aquarii		24.8	42.8	......	18.0	35.6	53.2	10.8	21 24 20.87	— 2.93	+ 0.07	38.88	21 23 39.13	38.52
	β Cephei		......	......	33.6	25.0	15.2	6.4	58.0	21 28 15.68	— 51.14	— 1.66	38.89	21 26 43.99	43.95
	ε Pegasi		34.4	52.4	10.0	27.6	45.6	3.4	21.6	21 37 27.89	....	— 0.09	38.90	21 36 48.90	48.41
	ι Aquarii		4.0	22.8	40.4	58.4	16.4	34.8	52.8	21 58 58.51	....	+ 0.16	38.94	21 58 19.73	18.88
	σ Aquarii		24.0	43.6	2.4	20.0	37.6	55.6	13.6	22 23 19.54	....	+ 0.12	38.98	22 22 40.68	41.46
	ξ Pegasi		43.2	1.6	19.6	37.2	54.8	13.2	30.8	22 34 37.20	....	— 0.10	39.00	22 33 58.10	58.48
	λ Aquarii		31.6	49.2	7.6	25.2	42.8	0.4	......	22 45 16.13	+ 8.88	+ 0.08	39.02	22 44 46.07	46.57
	α Ursæ Minoris		3.2	41.2	19.2	58.0	35.6	13.6	52.0	22 54 57.54	....	+ 1.12	39.03	22 54 19.63	21.71
	β Ceti		46.0	4.8	23.2	41.6	0.4	18.8	37.6	0 36 41.77	....	+ 0.20	39.20	0 36 2.77	3.24
	δ Piscium		40.0	57.6	16.0	33.2	50.8	8.8	26.4	0 41 33.26	....	— 0.08	39.21	0 40 53.97	54.21
	Moon, 1st L.		59.8	17.6	35.6	53.6	11.6	29.6	47.6	1 9 53.63	....	— 0.04	39.25	1 9 14.34	......
	θ^1 Ceti		17.2	34.8	52.8	10.8	28.0	46.0	4.0	1 17 10.51	....	+ 0.09	39.27	1 16 31.33	31.57
	μ Piscium		5.6	23.6	41.6	58.8	16.8	34.0	52.0	1 22 58.91	....	— 0.06	39.28	1 22 19.57	19.71
	ν Piscium		24.0	42.0	59.6	17.2	34.2	52.0	10.0	1 34 17.00	....	— 0.06	39.30	1 33 37.64	37.80
	ο Piscium		14.8	32.8	50.4	8.4	26.4	43.6	1.6	1 38 8.29	....	— 0.08	39.39	1 37 28.91	28.77
30	ι Piscium	W.	......	......	......	......	11.2	30.8	48.4	23 33 30.13	— 35.24	— 0.12	— 41.56	23 32 13.21	13.94
	20 Piscium		2.0	20.0	37.2	54.8	12.8	30.4	48.0	23 40 55.03	....	+ 0.09	41.58	23 40 13.54	13.49
	27 Piscium		48.0	5.6	23.2	40.8	58.4	16.0	34.0	23 51 40.86	....	+ 0.11	41.67	23 50 59 36	59.41
	α Andromedæ		21.6	41.2	1.6	21.2	40.8	0.8	20.8	0 1 21.14	....	— 0.77	41.63	0 0 38.74	38.78
	γ Pegasi		18.8	36.8	54.8	12.8	30.8	48.8	7.6	0 6 12.91	....	— 0.37	41.63	0 5 30.91	30.97
	α Cassiopeæ		13.6	44.0	15.6	46.8	17.2	48.8	20.8	0 32 46.69	....	— 2.10	41.69	0 32 2.90	3.00
	β Ceti		49.2	7.2	26.0	44.4	2.8	21.2	40 4	0 36 44.46	....	+ 0.39	41.70	0 36 3.15	3.23
	δ Piscium		42 8	0.8	18.4	36.0	53.6	11.6	29.2	0 41 36.06	....	— 0.17	41.71	0 40 54.18	54.20
	20 Ceti		9.6	27.2	44.4	2.0	19.6	37.6	54.8	0 46 2.17	....	+ 0.05	41.72	0 45 20.50	20.55
	α Arietis		29.2	48.4	7.2	26.4	45.2	4.4	23.6	1 59 26.34	....	— 0.60	41.88	1 58 43.86	43.88
	Moon, 1st L.		25.2	43.6	1.6	19.6	38.0	56.0	14.4	2 6 19.77	....	— 0 21	41.89	2 5 37.67	......
	ξ Ceti		0.4	18.4	36.4	53.6	11.2	29.2	47.2	2 20 53.77	....	— 0.20	41.92	2 20 11.65	11.47
	α Ceti		15.6	33.2	51.2	8.8	26.0	44.0	1.6	2 55 8.63	....	— 0.09	41.99	2 54 26.55	26.72
	δ Arietis		50.4	9.2	28.0	46.8	6.8	23.6	42.0	3 3 46.69	....	— 0.50	42.01	3 3 4.18	3.76
	α Persei		2.0	29.2	55.6	22.8	49.6	16.8	44.0	3 14 22.86	....	— 1.67	42.04	3 13 39.15	39.05
	ξ Tauri		51.6	9.6	27.2	44.8	2.4	20.4	38.4	3 19 44.91	....	— 0.23	42.05	3 19 2.63	2.78
31	δ Capricorni	E.	34.0	52.0	10.0	......	......	......	......	21 38 52.00	+ 36.68	+ 0.37	— 45.01	21 38 44.04	41.07
	λ Aquarii		38.0	56.0	14.0	31.2	49.2	6.8	24.8	22 45 31.43	....	+ 0.18	45.03	22 44 46.49	46.47
	α Piscis Australis		3.6	24.0	44.0	4.4	24.8	45.6	6.0	22 50 4.63	....	+ 0.73	45.04	22 49 20.22	20.23
	α Pegasi		8.0	26.0	44.0	2.0	20.0	38.0	56.0	22 58 2.00	....	— 0.32	45.17	22 57 16.51	17.22
	ι Piscium		6.4	23.6	41.2	59.2	17.2	34.8	52.0	23 32 59.20	....	— 0.10	45.24	23 32 13.86	13.93
	20 Piscium		5.6	23.6	40.8	58.0	16.0	33.6	51.2	23 40 58.40	....	+ 0.08	45.26	23 40 13.22	13.36
	27 Piscium		51.6	9.6	27.6	44.0	2.4	20.0	37.6	23 51 44.74	....	+ 0.09	45.29	23 50 59 54	59.30
	α Andromedæ		24.4	44.8	4.8	......	44.8	4.8	24.8	0 1 24.73	— 0.01	— 0.67	45.31	[illegible]	[illegible]
	γ Pegasi		22.8	40.8	58.8	16.8	34.8	52.8	10.8	0 6 16.80	....	— 0.32	45.33	[illegible]	[illegible]
	Polaris		36.0	0.9	19.6	29.6	40.6	4.4	29.6	1 7 31.40	....	— 47.62	45.43	1 5 58.35	58.74
	χ Piscium		30.0	48.0	6.0	......	......	......	......	1 33 48.00	+ 35.21	— 0.10	45.49	1 33 37.65	37.78
	α Arietis		32.4	51.2	10.8	29.6	48.8	......	26.8	1 59 23.27	+ 6.36	— 0 52	45.53	[illegible]	[illegible]
	ξ^1 Ceti		56.0	14.0	31.2	48.8	6.8	24.8	42.0	2 5 49.09	....	— 0.18	45.55	2 5 3.36	3.36
	ξ^2 Ceti		3.6	22.0	39.2	56.8	14.4	32.8	50.0	2 20 56.97	....	— 0.17	45.59	2 20 11.21	11.48
	α Ceti		20.0	......	......	......	29.6	47.6	......	2 55 12.40	+ 0.13	— 0.07	45.63	2 54 26.83	26.73
	Moon, 2d L.		45.6	4.0	22.0	40.4	......	......	......	3 7 13.00	+ 27.64	— 0.27	— 45.67	3 6 51.70	......

Longitude of junction of the Gila and Colorado—Continued.

DATE.	OBJECT.	LAMP.	CHRONOMETER TIME OF TRANSIT. I.	II.	III.	IV.	V.	VI.	VII.	MEAN OF OBS'D WIRES	CORRECTIONS FOR— Imperfect transits.	Instrument.	Chronometer.	OBSERVED A.R.	TABULAR A.R.
1849.			s.	s.	s.	s.	s.	s.	s.	h. m. s.	m. s.	s.	s.	h. m. s.	s.
Nov. 1	Polaris	W.	......	41.6	0.8	17.0	29.2	48.4	13.2	1 12 55.03	— 38.97	— 30.80	— 46.76	1 5 58.50	58.51
	μ Piscium		13.6	31.2	49.2	6.8	24.0	41.6	59.6	1 23 6.57	....	0.07	46.78	1 22 19.72	19.67
	ν Piscium		32.0	49.6	7.2	24.4	42.0	59.6	17.6	1 34 24.63	....	0.07	46.79	1 33 37.77	37.77
	α Arietis		34.0	53.6	12.0	31.6	50.0	9.2	28.0	1 59 31.20	....	0.34	46.82	1 58 44.04	43.89
	ξ^1 Ceti		57.2	15.2	32.4	50.4	8.0	25.6	43.6	2 5 50.34	....	0.11	46.84	2 5 3.39	3.37
	ξ^2 Ceti		5.6	22.8	40.8	58.4	16.0	33.6	51.6	2 20 58.40	....	0.11	46.86	2 20 11.43	11.49
	χ Ceti		26.4	43.6	1.6	18.8	36.8	54.0	12.0	2 36 19.03	....	0.04	46.88	2 35 32.11	32 07
	α Ceti		20.8	38.4	56.0	14.0	30.8	48.8	6.4	2 55 13.60	....	0.05	46.90	2 54 26.65	26.74
	δ Arietis		55.6	13.6	32.6	51.2	9.6	28.0	47.2	3 3 51.03	....	0.28	46.91	3 3 3.84	3.80
	α Polaris		6.4	32.8	0.4	27.2	54.0	20.8	47.6	3 14 27.03	....	0.93	46.92	3 13 39.18	39.09
	ξ Tauri		56.0	14.0	32.0	50.0	7.2	25.2	43.2	3 19 49.66	....	0.13	46.93	3 19 2.60	2.80
	e Tauri		56.4	14.4	32.4	50.4	8.0	26.0	44.0	3 40 50.23	....	0.15	46.96	3 40 3.12	3.11
	λ Tauri		16.0	34.0	52.0	10.0	28.0	46.0	4.0	3 53 10.00	....	0.17	46 98	3 52 22.85	22.55
	Moon, 2d L		23.2	42.4	1.2	19.6	38.0	57.2	16.0	4 9 19.66	....	0.23	46.99	4 8 32.44	......
	γ Tauri		8.8*	26.8	44.8	2.8	20.8	38.8	56.8	4 12 2.80	....	0 22	47.00	4 11 15.58	15.75
	α Tauri		11.6	29.6	48.0	6.8	24.4	42.8	0.8	4 28 6.29	....	0.23	47.02	4 27 19.04	19.09
	o^1 Orionis		55.6	14.0	32.0	50.0	8.0	26.0	44.0	4 44 49.96	....	0.20	47.04	4 44 2.70	2.97
	ι Tauri		59.2	17.6	36.4	55.6	14.0	32.8	52.0	4 54 55.37	....	0.31	47.05	4 54 8.01	7.80
2	α Tauri	E.	......	......	......	8.8	27.6	45.6	4.0	4 28 36.50	— 27.42	+ 0.06	— 49.89	4 27 19.15	19.10
	o^1 Orionis		58.4	16.4	34.8	52.4	10.8	28.8	46.8	4 44 52.63	....	0 05	50.01	4 44 2.67	3.02
	ι Tauri		0.8	19.6	38.8	57.6	16.8	35.6	54.4	4 54 57.66	....	0.08	50.02	4 54 7.72	7.92
	Moon, 2d L		4.4	23 6	42.4	1.6	20.8	39.2	58.4	5 13 1.49	....	0.06	50.05	5 12 11.50	......
	β Tauri		38.8	58.8	18.8	38.8	58.8	18.8	38.8	5 17 38.80	....	0.01	50.06	5 16 48.85	48.61
	δ Orionis		18.0	36.0	52.8	10.8	28.4	45.6	3.6	5 25 10.74	....	0.00	50.07	5 24 20.67	20.62
*	ζ Tauri		34.0	53.0	12.0	30.4	49.6	8.8	27.2	5 29 30.71	....	0.08	50.08	5 28 40.71	40.70
†	α Orionis		59.6	17.6	35.6	53.8	10.8	28.4	46.0	5 47 53.11	....	0.02	50.10	5 47 3.03	2.86
	η Geminorum		41.6	0.8	20.0	39.2	58.0	17.2	36.0	6 6 38.97	....	0.08	50.12	6 5 48.93	48.90
	δ Ursæ Minoris ...		......	......	35.6	32.0	25.6	24.0	23.2	6 26 28.08	—4 56.60	— 3.36	50.15	6 20 37.97	38.03
	51 (Hev.) Cephei .		58.0	11.6	20.4	22.4	29.2	36.4	42.4	6 29 22.91	....	+ 4.15	50.15	6 28 36.91	36.92
3	e Tauri	W.	1.2	19.2	37.2	55.2	12.8	30.8	48.8	3 40 55.03	....	0.00	— 52.07	3 40 2.96	3.13
	γ^1 Eridani		0.0	18.0	36.0	54.0	12.0	30.4	48.4	3 51 54.11	....	0.00	52.09	3 51 2.02	2.10
	γ Tauri		13.2	31.6	49.6	7.6	26.0	44.4	2.4	4 12 7.83	....	0.00	52.11	4 11 15.72	15.77
	α Tauri		16.8	34.8	52.8	11.2	29.6	47.6	6.8	4 28 11.37	....	0.00	52.13	4 27 19.24	19.12
	o^1 Orionis		1.2	19.2	37.2	55.2	13.2	31.2	49.2	4 44 55.20	....	0 00	52.15	4 44 3.05	3.03
	α Aurigæ		13.6	38.8	4.0	29.2	53.6	19.2	44.8	5 6 29.03	....	0.00	52.17	5 5 36.86	37.01
	o Tauri		32.8	51.6	10.8	29.6	48.4	7.6	26.8	5 19 29.66	....	0.00	52.19	5 18 37.47	37.44
	δ Orionis		20.4	37.6	55.2	13.2	30.0	48.0	5 6	5 25 12.86	....	0.00	52.20	5 24 20.66	20.64
	ζ Tauri		36.8	55.6	14.4	32.8	51.6	10.4	29.2	5 29 32.97	....	0.00	52.21	5 28 40.76	40.72
	α Orionis		2.0	20.0	37.6	55.2	12 8	34.4	48.4	5 47 55.20	....	0.00	52.23	5 47 2.97	2.88
	η Geminorum		44.0	3.2	22.0	41.2	0.0	19.2	38.4	6 6 41.14	....	0.00	52.25	6 5 48.89	48.92
	μ Geminorum		47.6	6.8	26.4	44.8	......	......	......	6 14 16.40	+ 28.52	0.00	52.27	6 13 52.65	52.67
	Moon, 2d L		37.2	56.4	15.6	34.8	53.2	12.8	32.0	6 17 34.57	....	0.00	52.28	6 16 42.29	......
	γ Geminorum		59.6	18.0	36.0	54.8	12.8	30.8	49.6	6 29 54.51	....	0.00	52.29	6 29 2.22	2.25
	α Canis Majoris ..		29.6	48.0	6.0	24.8	42.8	1.2	20.0	6 39 24.63	....	0.00	52.31	6 38 32.32	32.15
4	γ Tauri	E.	15 2	33.2	51.6	9.6	27.6	46.0	4.4	4 12 9.66	....	0 00	— 54.11	4 11 15.55	15.79
	α Tauri		18.0	36.4	54.8	13.2	31.6	50.0	8.0	4 28 13.14	....	0.00	54.13	4 27 19.01	19.14
‡	o^1 Orionis		2.8	20.8	38.8	56.8	15.6	33.2	51.6	4 44 57.09	....	0.00	54.15	4 44 2.94	3.05
	ι Tauri		5.6	24.0	43.2	2.0	20.8	40.0	58.4	4 55 2.00	....	0.00	54.18	4 54 7.82	7.96
	α Aurigæ		15.4	40.8	6.4	31.2	56.4	21.2	46.8	5 6 31.17	....	0.00	54.20	5 5 36.97	37.04
	β Tauri		42.8	2.8	22.8	42.8	2.8	22.8	42.8	5 17 42.80	....	0.00	54.22	5 16 48.58	48 66
	δ Orionis		22.4	40.0	57.6	14.8	32.0	50.0	7.6	5 25 14.91	....	0.00	54.22	5 24 20.69	20.66
	α Leporis		......	......	43.2	1.2	20.2	38.0	56.8	5 27 19.88	— 18.47	0.00	54.25	5 26 7.16	7.05
	α Orionis		3.6	21.6	39.6	57.6	14.8	32.8	50.4	5 47 57.20	....	0.00	54 27	5 47 2.93	2.90
	η Geminorum		46.4	5.4	24.4	43.6	2.4	21.2	40.0	6 6 43.34	....	0.00	54.28	6 5 49.06	48.95
	μ Geminorum		49.6	8.8	28.0	47.2	6.0	25.2	44 0	6 14 46.97	....	0.00	54.30	6 13 52.67	52.70
	δ Ursæ Min., S. P.		......	......	......	33.6	28.8	......	22.8	6 28 6.07	—6 35.73	0.00	54.31	6 20 35.03	37.30
	51 (Hev.) Cephei ...		......	......	24 8	......	38.0	43.6	......	6 33 35.47	4 4.67	0.00	54.31	6 28 38.49	37.86
	γ Geminorum		......	20.0	38.8	56.4	14.8	33.2	52.0	6 30 5.87	9.18	0.00	— 54.32	6 29 2.37	2.28

* Wire II recorded 52.0s. † Wire IV recorded 54.8s. ‡ Wire II recorded 18.8s.

Longitude of junction of the Gila and Colorado—Continued.

DATE.	[illegible]	[illegible]	CHRONOMETER TIMES OF TRANSIT. I.	II.	III.	IV.	V.	VI.	VII.	MEAN OF OBS'D WIRES	CORRECTIONS FOR—* Imperfect ransits.	Instrument.	Chronometer.	OBSERVED A.R.	TABULAR A.R.
[illegible]			s.	s.	s.	s.	s.	s.	s.	h. m. s.	m. s.	s.	m. s.	h. m. s.	s.
Nov. 4	α Canis Majoris...	E.	32.0	50.0	8.4	26.8	46.8	3.6	21.6	6 39 26.74	....	[illegible]	— [illegible]	6 38 32.41	32.18
	ε Canis Majoris...		38.4	58.4	18.4	38.4	58.4	......	......	6 53 18.40	+ 20.05	0.00	54.34	6 52 44.11	43.85
	ζ Geminorum ...		10.0	28.8	47.6	6.0	24.8	44.0	2.8	6 56 6.29	....	0.00	54.34	6 55 11.95	11.99
	λ Geminorum		26.8	45.2	4.0	22.0	40.0	58.8	16.5	7 10 21.90	....	0.00	54.35	7 9 27.55	27.53
	δ Geminorum		......	......	......	3.2	22.4	41.2	0.0	7 12 31.70	— 28.45	0.00	54.35	7 11 8.90	[illegible]
	Moon, 2d L.....		32.4	51.6	10.4	29.6	48.8	7.6	26.8	7 21 29.60	....	[illegible]	[illegible]	7 20 35.24	......
	68 Geminorum		1.2	19.2	38.0	56.0	14.4	32.8	50.8	7 25 56.06	....	0.00	54.37	7 25 1.69	1.98
	α Canis Majoris...		26.8	45.2	2.8	20.4	38.4	56.0	14.0	7 32 20.51	....	0.00	54.38	7 21 26 13	[illegible]
	β Geminorum		1.2	21.2	41.6	1.2	21.2	41.2	1.2	7 37 1.26	....	0.00	54.39	7 36 6.87	6.87
5	μ Geminorum	W.	50.4	9.6	28.8	48 0	7.2	26.0	45.2	6 14 47.86	....	+ 0.17	— 55.17	6 13 52.86	52.73
	δ Ursæ Min., S. P.		......	......	......	37.6	35.2	......	26.4	6 28 13.07	—6 34.77	— 6.92	55.18	6 20 36.10	36.95
	51 (Hev.) Cephei ..		.....	......	......	......	30.8	35.2	43.2	6 41 36.40	12 12.23	+ 8.55	55.18	6 28 37.54	[illegible]
	γ Geminorum		2.0	20.4	38.8	57.2	15.6	34.0	42.4	6 29 57.20	....	0.12	55.18	6 29 2.14	2.30
	α Canis Majoris...		......	......	9.2	27.6	45.6	3.6	22.4	6 39 45.68	— 18.33	— 0.12	55.20	6 38 32.03	[illegible]
	ε Canis Majoris...		......	......	19.6	39.2	59.2	19.2	39.6	6 53 59.36	20.05	0.23	55.22	6 52 43.86	43.88
	λ Geminorum		27.6	46.0	4.0	22.8	40.8	59.2	17.6	7 10 22.55	....	+ 0.12	55.25	7 9 27.42	27.55
	68 Geminorum		2.0	20.0	38.4	56.8	14.8	33.6	52.0	7 25 56.80	....	0.12	55.27	7 25 1.65	2.00
	α Canis Minoris...		28.8	44.8	3.6	21.6	39.2	56.8	15.2	7 32 21.43	....	0.04	55.28	7 31 26.19	26.09
	β Geminorum		2.4	22.0	42.4	2.0	22.0	42.0	2.0	7 37 2.14	....	0.22	55.28	7 36 7.05	6.90
	15 Argus		6.8	26.0	45.6	4.4	23.2	42.8	2.4	8 2 4.46	....	— 0.18	55.31	8 1 [illegible]	[illegible]
	ζ Cancri		35.2	53.6	12.0	30.4	49.2	7.6	26.0	8 4 30.57	....	+ 0.13	55.31	8 3 35.39	35.13
	Moon, 2d L.....		28.0	47.2	6.0	25.2	43.6	2.4	21.2	8 23 24.80	....	0.12	55.33	8 22 29.59	......
	δ Cancri		7.6	26.0	44.0	3.6	21.6	40.4	59.2	8 37 3.20	....	0.13	55.36	8 36 7.97	8.03
	ε Hydræ		50.8	8.8	26.4	44.0	1.6	19 2	37.2	8 39 44.00	....	0.05	55.36	8 38 48.69	48.73
	α Cancri		16.8	34.8	52.8	10.8	28.8	46.8	4.8	8 51 10.80	....	0.09	55.38	8 50 15.15	15.43
6	α Canis Majoris...	E.	34.0	53.6	11.6	29.6	48.0	6.4	24.8	6 39 29.71	....	0.00	— 57.31	6 38 32.40	[illegible]
	ε Canis Majoris...		41.2	1.2	21.2	41.2	1.2	21.2	41.2	6 53 41.20	....	[illegible]	[illegible]	6 52 43.87	43.91
	ζ Geminorum		......	......	50.4	9.2	28.0	47.2	5.6	6 56 28.08	— 18.80	0.00	57.33	6 55 11.95	12.05
	λ Geminorum		30.0	48.0	6.0	24.4	43.6	1.6	20.0	7 10 24.80	....	0.00	57.37	7 9 27.43	27.57
	β Canis Minoris...		4.0	22.0	40.0	57.6	16.0	33.6	51.2	7 19 57.77	....	0.00	57.38	7 19 0.39	0.33
	68 Geminorum		4.0	22.8	41.2	59.2	17.6	36.0	54.0	7 25 59.26	....	0.00	57.39	7 25 1.87	[illegible]
	α Canis Minoris...		30.8	48.4	6.0	23.6	41.6	59.2	16.8	7 32 23.77	....	0.00	57.39	7 31 26.38	[illegible]
	β Geminorum		4.4	24.4	44.4	4.4	24.4	44.4	4.4	7 37 4.40	....	0.00	57.39	7 36 7.01	6.94
	15 Argus		......	......	47.2	6.4	26.0	45.2	4.8	8 2 25.92	— 19.22	0.00	57.42	8 1 9.28	[illegible]
	[illegible]		26.0	44.0	1.6	18.8	......	54.8	12.8	8 9 16.33	+ 2.94	[illegible]	[illegible]	8 8 21.84	21.84
	θ Cancri		......	21.2	40.0	58.4	16.8	35.6	54.0	8 24 7.66	— 9.28	0.00	57.45	8 23 0.93	1.19
	δ Cancri		10.0	28.0	47.2	5.6	24.0	42.4	1.2	8 37 5.49	....	0.00	57.47	8 36 8.02	8.16
	ε Hydræ..........		......	10.8	28.8	46.0	3.6	22.0	39.6	8 39 55 13	— 8.86	0.00	57.47	8 38 48.60	48.76
	α Cancri		19.2	37.2	55.2	12.8	31.2	49.2	7.2	8 51 13.14	....	0.00	57.49	8 50 15.65	[illegible]
	ξ Cancri		42.4	1.6	20.8	......	58.4	18.0	37.2	9 1 39.73	— 0.01	0.00	57.50	9 0 42.22	[illegible]
	Moon, 2d L.....		38.4	57.2	15.6	34.0	52.8	11.2	29.6	9 22 34.11	....	0.00	57.53	9 21 36.58	......
[illegible]	Moon, 1st L	E.	5.5	24.5	43.0	1.8	20.5	39.5	58.5	20 16 1.90	....	+ 0.24	+ 12 22.04	20 28 24.18	......
	ζ Cygni...........		9.5	30.0	50.0	10.0	30.5	50.5	11.0	20 54 10.21	....	— 0.44	12 22.04	21 6 31.81	[illegible]
	ι Capricorni......		34.5	[illegible]	11.0	29.5	47.5	6.3	24.5	21 1 29.40	....	+ 0.24	12 22.04	21 13 51.68	51.65
	α Cephei		......	......	......	..!...	15.5	54.0	30.8	21 3 53.43	—1 14.70	— 1.45	12 22.04	21 14 59.32	59.43
	β Aquarii		23.0	40.5	58.5	16.2	33.5	51.5	9.8	21 11 16.14	....	+ 0.08	12 22.04	21 23 38.26	38.20
	[illegible]		......	......	[illegible]	32.8	13.8	5.0	56.0	21 15 13.92	— 51.14	— 2.11	12 22.04	21 27 42.71	42.60
	[illegible]		32.5	50.5	8.5	26.0	44.0	1.5	19.5	21 24 26.07	....	0.12	12 22.04	21 36 47.99	48.09
†22	Moon, 1st L	E.	34.4	52.8	11.2	29.2	47.6	6.4	24.4	22 10 29.43	....	0.00	— 1 29.88	22 8 59.55	......
	σ Aquarii.........		17.2	35.4	52.8	10.8	[illegible]	46.8	4.8	22 24 10.91	....	0.00	1 29.88	22 23 41.03	40.98
	ζ Pegasi..........		34.4	52.4	10.4	......	45.6	3.6	21.6	22 35 28.00	— 0.01	0.00	1 29.88	22 38 58.11	58.15
‡23	[illegible]	E.	42.8	0.8	18.4	35.6	[illegible]	10.8	[illegible]	21 59 35.71	....	0.00	— 1 32.22	21 58 3.49	3.53
	θ Aquarii.........		32.4	50.4	8.4	26.4	44.4	2.4	[illegible]	23 10 26.46	....	0.00	1 32.24	22 8 54.22	53.58
	σ Aquarii.........		19.6	37.6	55.6	13.6	30.8	48.8	7.2	23 24 13.31	....	0.00	1 32.26	[illegible]	[illegible]
	ζ Pegasi		37.2	54.8	12.4	30.4	48.4	6.0	24.0	23 35 30.46	....	0.00	1 32.28	22 33 58.18	58.14
	λ Aquarii		25.2	43.2	1.2	18.8	36.0	54 0	12.0	23 46 18.63	....	0.00	1 32.29	22 44 46.34	46.25
	α Piscis Australis..		50.8	11.2	32.0	52.4	12.4	32.4	[illegible]	23 50 52.06	....	0.00	— 1 32.30	22 49 19.76	19.87

* Chronometer 2475. † Chronometer 719. ‡ Wire IV recorded 34.6s. All these wires increased 10s.

Longitude of junction of the Gila and Colorado—Continued.

DATE.	OBJECT.	LAMP.	CHRONOMETER TIMES OF TRANSIT. I.	II.	III.	IV.	V.	VI.	VII.	MEAN OF OBS'D WIRES.	CORRECTIONS FOR— Imperfect transits.	Instrument.	Chronometer.	OBSERVED A.R.	TABULAR A.R.
1849.			*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h. m. s.*	*s.*	*s.*	*m. s.*	*h. m. s.*	*s.*
Nov. 23	Moon 1st L.....	E.	46.0	4.0	22.0	40.0	58.4	16.4	34.4	23 0 40.17	....	0.00	— 1 32.30	22 59 7.87	......
	φ Aquarii.........		11.2	29.2	46.2	4.4	22.0	40.0	58.0	23 8 4.43	....	0.00	1 32.31	23 6 32.12	32.27
	χ Aquarii.........		47.2	4.8	22.8	40.8	58.8	16.4	34.4	23 12 40.74	....	0.00	1 32.32	23 11 8.42	3.34
24	σ Aquarii.........	E.	22.0	40.0	58.0	16.0	34.0	52.0	10.0	22 24 16.00	....	+ 0.14	— 1 35.09	22 22 41.05	40.95
	ζ Pegasi..........		39.2	57.6	15.6	33.2	52.8	8.8	26.8	22 35 33.43	....	— 0.12	1 35.11	22 33 58.20	58.13
	λ Aquarii.........		27.6	46.0	3.6	21.2	38.4	56.8	14.4	22 46 21.14	....	+ 0.10	1 35.12	22 44 46.12	46.24
	α Piscis Australis.		53.6	14.0	34.0	54.4	14.8	35.6	55.6	22 50 54.57	....	0.39	1 35.12	22 49 19.84	19.86
	φ Aquarii........		14.0	32.0	49.6	7.2	24.8	42.4	0.4	23 8 7.20	....	0.08	1 35.15	23 6 32.13	32.25
	χ Aquarii.........		50.0	8.0	26.0	43.6	1.2	19.6	37.2	23 12 43.66	....	0.12	1 35.15	23 12 8.63	8.33
	20 Piscium.........		55.2	13 2	30.8	48.4	6.0	23.6	40.8	23 41 28.29	....	0.04	1 35.18	23 40 13.15	13.24
	Moon, 1st L ...		34.0	52.0	10.0	28.0	46.0	4.0	22.0	23 51 28.00	....	0.09	1 35.21	23 49 52 88	......
	33 Piscium.........		20.8	38 8	56.4	14.0	31.6	49.2	6.8	23 59 13.94	....	0.08	1 35.22	23 57 38.80	38.75
	γ Pegasi..........		11.6	30.0	48.0	6.0	24.0	42.0	0.8	0 7 6.06	....	— 0.17	1 35.23	0 5 30.66	30.76
25	20 Piscium.........	W.	57.6	15.6	32.2	50.8	8.0	......	43.2	23 41 44.73	+ 5.86	0.00	— 1 37.36	23 40 13.23	13.22
	27 Piscium.........		42.8	0.4	18.4	35.6	53.6	12.4	28.8	23 52 36.00	....	0.00	1 37.38	23 50 58.62	59.06
	33 Piscium.........		22.8	40.8	58.4	16.4	34.0	51.6	9.6	23 59 16.23	....	0.00	1 37.38	23 57 38.85	38.74
	α Andromedæ		......	36.0	56.0	16.4	36.0	56.0	16.0	0 2 26.13	— 9.97	0.00	1 37.39	0 0 36.77	38.52
	γ Pegasi..........		14.0	32.0	50.0	8.0	26.0	44.0	2.0	0 7 8.00	....	0.00	1 37.39	0 5 30.61	30.75
	δ Piscium.........		38.4	56.0	14.0	31.6	......	......	......	0 42 5.00	+ 26.52	0.00	1 37.44	0 40 54.08	53.96
	Moon, 1st L		......	58.8	16.8	34.8	52.8	10.4	28.4	0 43 43.67	— 8.96	0.00	1 37.44	0 41 57.27	.....
	20 Ceti............		......	22.4	40.0	58.0	15.6	52.8	50.8	0 47 6.60	8.79	0.00	1 37.44	0 45 20.37	20.26
27	Moon, 1st L....	E.	57.0	15.5	33.5	52.0	10.0	28.5	47.0	2 20 51.93	....	— 0.68	+ 12 25.83	2 33 17.08	......
	μ Ceti............		32.0	50.0	8.0	25.5	43.5	1.5	19.0	2 24 25.64	....	0.69	12 25.83	2 36 50.78	50.58
	α Ceti............		8.0	26.0	43.5	1.0	18.5	36.5	54.0	2 42 1.07	....	0.25	12 25.83	2 54 26.65	26.90
	δ Arietis		43.5	2.5	21.0	39.5	58.0	17.0	35.5	2 50 39.57	....	1.44	12 25.83	3 3 3.96	3.92
	α Persei..........		57.5	24.5	51.5	18.0	45.0	12.5	39.5	3 1 18.36	....	4.81	12 25.83	3 13 39.98	39.38
29	ε Tauri..........	E.	43.2	11.2	29.2	46.2	......	......	......	3 41 19.95	+ 26.81	— 0.80	— 1 42.73	3 40 3.23	3.41
	λ Tauri..........		......	......	49.2	6.4	24.8	42.4	......	3 54 15.70	— 8.91	0.91	1 42.75	3 52 23.06	22.92
	γ Tauri..........		5.2	23.6	42.0	0.0	18.0	36.4	54.4	4 13 59.94	....	1.17	1 42.77	4 12 16.00	16.10
	α Tauri..........		8.8	26.8	45.2	3.2	22.0	40 4	58.4	4 29 3.54	....	1.24	1 42.79	4 27 19.51	19.53
	Moon, 1st L....		20.4	38.8	58.0	16.4	35.2	54.4	13.2	4 39 16.63	....	1.31	1 42.81	4 37 32.51	......
	ι Tauri		56.4	15.2	34.0	52.8	12.0	30.8	49.6	4 55 52.97	....	1.67	1 42.82	4 54 8.48	8.33
	α Aurigæ.........		9.2	34.4	59.6	24.8	50.4	15.2	40.8	5 7 24.91	....	4.40	1 42.84	5 5 37.67	37.67

The following are the results from the observations at the observatory near the junction of the Gila and Colorado:

	h. m. s.		*h. m. s.*
Oct. 3	7 38 47.04	Nov. 1	7 38 30.58
4	37.61	2	32.39
5	33.82	3	29.66
6	27.69	4	28.44
7	33.70	5	30.30
23	5.84	6	22.42
24	31.95	20	32.43
25	37 40.18	22	27.53
26	38 31.64	23	23.44
27	26.66	24	45.40
28	23.62	25	14.99
29	16.17	27	25.72
30	21.74	29	25.25
31	9.14		

	h. m. s.
Mean	7 38 25.75
Longitude of the same, computed in the field from the Greenwich ephemeris for 1849	7 38 12.53
Difference	13.22

	s.
Probable error of single observation	± 8.71
Probable error of mean result	± 1.71

III.—*Latitude of Camp Riley, near Initial Point on Pacific, determined*

Date.	5461 5507	5596 5620	5658 5708	5765 5937	6094 6129	6091 6482	6091 6528	6246 6482	6246 6528	6428 6642	6428 6647	6476 6642	6476 6647	6724 6741	6761 6814	6867 6893
	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
July 25		45.09		45.41	45.50					40.36	42.56	44.30		37.52		
26		47.04		43.80												
27	44.97	49.50		40.50												
28		45.66		42.85												
Aug. 2		44.82		42.10	43.82		44.20			39.31	42.67	43.18	46.55			
3	45.14					44.49	44.46									
4	44.54			43.20												
6	43.49	45.52														
7	46.69			41.96												
11			41.18	46.06				44.80	46.33					39.64		46.61
13								43.01	43.17					44.12		41.72
14				42.41		45.58	45.14							41.38		42.62
17				42.47		43.91	41.82									47.36
18				45.08		42.35	42.94							38.68		44.27
	44.97	46.27	41.18	43.26	44.66	44.08	43.71	43.91	44.75	39.84	42.62	43.74	46.55	40.27	41.32	44.52

Date.	5918 5985	6091 6482	6091 6528	6246 6482	6246 6528	6652 6754	6661 6754	6678 6754	6865 6952	7035 7082	7035 7125	7055 7088	7055 7125	7176 7324	7193 7324	7421 7476
	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
Aug. 21	46.67		45.39													
22		43.05	43.42	44.79	45.25			39.55	40.92	44.66		45.83		35.75		
23	44.63	39.27				40.34	41.56	39.45	37.60	44.07		45.05				
24	46.96	44.43	45.00	42.24	46.21				41.17	49.69	47.72	48.59	46.62	36.17	38.60	46.34
25	46.22	45.05	48.66			43.13	44.34	42.65	41.71	44.72	43.51	44.55	43.26			
Sept. 4		44.63	44.00			43.08	42.59	41.12	42.83			44.93	41.46	38.87	40.94	43.06
5		47.68	41.45					39.00	37.72							

There are 190 results obtained from observations on eighty-two different stars.

	° ′ ″
By giving the same weight to each observation (mean of all the observations) we have for the latitude ...	32 35 43.53
Latitude by giving to each pair a weight depending on the number of observations, (most probable)......	32 35 43.54
General mean of each night............	32 35 43.73
General mean of each pair............	32 35 43.56
General mean of all the observations	32 35 43.53

with a Zenith Telescope of 46-inch focal length: By W. H. Emory.

6959 7107	6959 7121	6959 7160	7193 7318	7418 7455	7547 7595	7651 7689	7759 7788	7827 7875	7908 7961	7997 8058	8056 8147	8058 8147	8268 8315	Mean of each night's observations.
"	"	"	"	"	"	"	"	"	"	"	"	"	"	° ′ "
44.36	43.55	44.14	47.69	44.25	39.57	42.68	40.91	......	......	......	......	......	......	32 35 43.19
......	......	......	......	......	......	......	......	......	......	......	......	......	......	45.42
......	......	......	......	......	......	......	......	......	......	......	......	......	......	44.09
......	......	......	......	......	......	......	......	......	......	......	......	......	......	44.96
......	......	......	......	43.04	40.81	......	39.55	......	44.37	......	46.39	......	......	43.14
......	......	......	......	......	......	......	......	......	......	......	......	......	......	44.70
......	......	......	......	......	......	......	......	......	......	......	......	......	......	43.87
......	......	......	......	......	......	......	......	......	......	......	......	......	......	44.51
......	......	......	......	......	......	......	......	......	......	......	......	......	......	[illegible]
47.20	46.85	47.21	46.48	41.98	40.85	43.07	40.50	......	40.59	......	......	......	......	43.95
44.56	45.36	......	......	......	38.89	45.02	39.00	42.58	40.81	......	......	41.94	43.84	42.62
45.01	46.00	46.24	......	......	......	......	......	......	......	......	......	......	......	44.30
42.78	41.83	43.63	......	43.76	......	44.17	39.07	42.16	38.59	......	......	......	......	42.59
44.87	45.91	46.37	......	41.70	......	46.83	40.66	46.70	......	41.85	......	44.12	43.84	43.74
														32 35 43.97 Mean of each night.
44.80	44.92	45.52	47.08	42.95	40.03	44.35	*39.95	43.81	41.05	41.85	46.39	43.03	43.84	32 35 43.63 Mean of each pair.
														32 35 43.80 Mean of observa'ns.

* Rejected. 7759 not well determined.

7567 7598	7605 7522	7605 7547	7629 7696	7629 7698	7659 7696	7659 7698	7815 7912	7971 8024	7971 8083	8125 8227	8268 8315	Mean of each night's observations.
"	"	"	"	"	"	"	"	"	"	"	"	° ′ "
......	......	......	......	......	......	......	......	......	......	......	......	32 35 46.03
......	41.10	44.87	......	36.42	......	43.23	46.33	39.92	42.00	42.15	......	42.30
......	......	......	......	39.40	......	46.76	44.43	40.41	37.00	43.39	......	41.60
49.14	......	......	40.76	40.40	47.93	47.57	49.93	43.21	42.68	44.73	44.18	44.79
......	......	......	......	......	......	......	......	......	......	......	......	44.34
42.83	......	......	......	37.13	......	45.00	45.80	40.43	39.24	43.08	43.77	42.31
......	......	......	......	......	......	......	......	......	......	......	......	41.46
												32 35 43.26 Mean of each night.
												32 35 46.48 Mean of each pair.
												32 35 43.32 Mean of observ'ns.

		"
Probable error in determinations of the latitude from a single pair	....	1.48
Limit of probable error in determinations of the latitude from the results of all the pairs	....	0.198

IV.—*Observations for latitude at Observatory near the junction of the Gila and Colorado rivers: By Lieut. A. W. Whipple.*

Date.	7480 7598	7547 7595	7950 7997	8058 8146	8280 8312	7 66	6867 6893	7107 7120	7176 7206	7302 7310	
1849.	° ′ ″	° ′ ″	° ′ ″	″	° ′ ″	° ′ ″	″	″	″	″	° ′ ″ *32 43 27.36
Oct. 6		32 43 37.81	32 43 38.61		32 43 48.97	32 43 51.92					32 43 37.16
7	28.44										32 43 41.60
8	25.74		42.49	41.31	44.24	47.93					32 43 43.17
9	29.04		40.56	43.40	47.48	51.31				40.43	32 43 44.94
10		35.37		43.21	42.82	50.93	44.31	41.96	36.82		32 43 51.31
11			41.72	44.66	43.23	50.31		41.39	38.10		32 43 44.31
12	27.40	39.34	46.27	46.04		54.44		42.59	39.11		32 43 42.63
13	26.05	36.54						44.59	37.78	39.96	32 43 37.95
15		37.76	39.97	40.39	42.88					39.47	32 43 39.92
Mean for each pair.	32 43 27.36	37.16	41.60	43.17	44.94	51.31	44.31	42.63	37.95	39.92	
Mean of nine pairs											32 43 42.54

* Rejected.

V.—*Triangulation by which the observed latitude and longitude of Camp Riley was transferred to the Initial Point of the boundary on the Pacific: By Major Emory.*

MEASUREMENT OF THE BASE LINE.

(Unit of measure, a metre graduated by Gambey, of Paris.)

1st measurement, with rods made of seasoned red wood	4536.7895 metres.
2d measurement, with steel wires belonging to Señor Salazar, surveyor of the Mexican commission	4536.60 "
	2) 3895
Result adopted	4536.6947

SOLUTION OF THE TRIANGLE.

Stations.	No. of observations.	Observed angles.	Distribution and error.	Spherical excess.	Plane angles and distances.	Logarithms.
		° ″ ″	″		° ′ ″	
East base	24	37 25 57.5	+ 0.033	00	37 25 57.53	9.7837811
West base	16	107 34 1.2	+ 0.033	00	107 34 1.23	
Initial point	24	35 0 1.2	+ 0.033	00	35 0 1.23	9.7585949
			+ 0.1			
East base to west base					4536.39	3.6567391
East base to initial point					7540.59	3.8774051
West base to initial point					4807.56	3.6819252

Calculation of the Geographical Position of the Initial Point.

Azimuth of the line from east base to initial point determined by measurement of angle made with meridian of the observatory, and also by various measurements of the elongations of Polaris: Counting from the south towards the west, 24° 31′ 31″.

Latitude of east base situated precisely in the meridian of observatory at Camp Riley, and determined, by direct measurement, to be south of it 1″.2; north latitude, 32° 35′ 42″.33.

East base to initial point $= K = 7540.59$ metres, $H = 32° 35' 42''.33$.

$P = 117° 03' 16''.5$; $Z = 24° 31' 31''$.

Log. K............	$= 3.8774051$	1st term H =	$32° 35' 42''.33$
Log. $\dfrac{1}{N \sin. 1''}$	$= 8.5093882$	2d term H =	$3' 42''.76$
Log. u''............	$= 12.3868933$	3d term H =	
		Lat. Initial Point =	$32° 31' 59''.57$

(2d term H) log. $(1 + E^2 \cos.^2 H)$	$= 0.0020139$
Log. u''	$= 2.3868933$
Log. cos. Z	$= 9.9589355$
Log. 2d term	$= 2.3478427$
2d term	$= 222''.76$

Log. u''	$= 2.3868933$
Log. sin. Z	$= 9.6181471$
	12.0050504
Log. cos. H	$= 9.9258689$
	$2.0791815 = \log. 120''$

P.	$= 117° 03' 16''.5$
$\dfrac{u'' \sin. Z}{\text{Cos. H.}}$	$= 2' 00''$
Long. Int. Pt.	$= 117° 05' 16''.5$

3d term H log. u''	$= 2.3868933$
Log. sin. Z	$= 9.6181471$
	2.0050404
	2
Log. $(u'' \sin. Z)^2$	$= 4.0100808$
Log. $(1 + e^2 \cos.^2 H)$	$= 0.0020139$
Log. $\dfrac{\text{Sin. } 1''}{2}$	$= 4.3845449$
Log. tang. H.........	$= 9.8057664$
	8.2024060

Calculation of the Geographical Position of Station "West Base."

Measured azimuth of base line $= Z = 61° 57' 28''.5$. Base line $= K = 4536.69$ metres.

1st term H.........	$= 32° 35' 42''.33$	Log. K..................	$= 3.6567391$
2d term H.........	$= 1' 09''.23$	Log. $\dfrac{1}{N. \sin. 1''}$	$= 8.5093882$
3d term H.........	$= 0' 00''.00$	Log. u''..................	$= 2.1661273$
H. or W. base	$= 32° 34' 33''.10$	Log. $(1 + e^2 \cos.^2 H)$	$= 0.0020139$
		Log. cos. Z.........	$= 9.6722077$
			1.8403489
		2d term	$= 69''.23$

Log. u''...............	$= 2.1661273$	3d term—	
Log. sin. Z.........	$= 9.9457651$	Log. u''..............	$= 2.1661273$
	2.1118924	Log. sin. Z.........	$= 9.9457651$
Log. cos. H	$= 9.9256623$		2.1118924
	2.1862301		2
2d term $P = 153''.54 = 2'\ 33''.54$		Log. $(u''\ \sin.\ Z)^2$	$= 4.2237848$
		Log. $(1 + e^2 \cos.^2 H)$	$= 0.0020139$
P..................	$= 117°\ 03'\ 16''.5$	Log. $\dfrac{\text{Sin. } 1''}{2}$	$= 4.3845449$
2d term..........	$= \quad 2'\ 33''.54$	Log. tang. H.........	$= 9.8057664$
P. or long. of West Base	$= 117°\ 05'\ 50''.04$		8.4141100

Calculation of the Azimuth of the line from Initial Point of the Boundary to East Base.

$$\text{Log K} = 3.8774050 = 7540.59. \quad Z' = 180 + Z - \frac{u''\ \sin.\ Z}{\text{Cos. } L'} \sin. \tfrac{1}{2}(L + L')$$

$\dfrac{1}{\text{N. sin. } 1''}$	$= 8.5093881$	Measured Z =	$24°\ 31'\ 16''$
Sin. Z	$= 9.6181471$		$+ 15$ err. in meridian.
	2.0049402		$24°\ 31'\ 31''$
Cos. L′	$= 9.9258689$		$180°$
	2.0790713		$204°\ 31'\ 31''$
$\text{Sin. } \dfrac{L + L'}{2}$	$= 9.7309790$		$1'\ 04''.5$
$64''.57$	$= 1.8100503$	$Z' =$	$204°\ 30'\ 26''.5$

VI.—*Azimuth of straight line from Initial Point on the Pacific to junction of Gila and Colorado.*

In the computation for the direction of the line, the longitude of the initial point and the longitude of the junction of the Gila and Colorado are taken as determined in the field by the observations compared with the moon's place, as given in the Nautical Almanac (Greenwich.) On arriving at Washington, I obtained from Professor Airy his corresponding observations, made at Greenwich, and it will be seen that a change has been made in the absolute longitude of both places, but fortunately no material change is discoverable in the relative longitude of the two places. Now, an inspection of the formula used will show that the *difference* in longitude is the element used in determining the azimuth of the line connecting the two points. Hence the change deduced from comparison with the corresponding Greenwich observations does not affect this result.

The preceding pages show the process by which the latitude and longitude of Camp Riley was transferred to the initial point of the boundary on the Pacific.

A word on the subject of the transfer to the "junction" of the latitude and longitude of the observatory near that point; the distance between them was so small that the transfer may be considered as having been accomplished by direct measurement.

Lieutenant Whipple's report to me, November 30, 1849, gives—

	° ′ ″
The longitude of observatory, $7^h\ 38^m\ 12^s.53$; in arc	114 33 07.95
The longitude of junction	114 32 51.61
Difference	16.34

	° ′ ″
Latitude of observatory, (see report of November 24)	32 43 43.96
Latitude of junction	32 43 32.3
Difference	11.66

These, corresponding with my computations founded on the same data, were adopted; but it must be observed, to prevent future misunderstanding, that it was impracticable to measure the azimuth from the junction of the two rivers, (then under water,) and a point, B, (see sketch,) was selected in the azimuth produced, ascertained by direct measurement to be 73.5 feet south and 1,070 feet west of the junction, and here the monument was placed and the azimuth measured from it. The geographical position of this monument is, consequently,

	° ′ ″
In north latitude	32 43 31.6
Uncorrected longitude	114 33 04.3

The computation of the azimuth and length of the line of boundary extending from the initial point on the Pacific coast, near San Diego, to the junction of the Gila and Colorado, was based on the following assumption:

	° ′ ″
Latitude of initial point on the Pacific	32 31 59.63
Latitude of junction of Gila and Colorado	32 43 32.2
Difference of longitude	2 32 24.9

We compute the azimuth and distance by the formulæ given by *Puissant, Traité de Geodesie*, Ed. III, Vol. 2, p. 316, using the following notation:

$a =$ equatorial radius $\qquad e =$ ellipticity $= \dfrac{a^2 - b^2}{b^2}$

$b =$ polar radius $\qquad$ Log. $e = 7.8273187$

$Z' =$ azimuth at the Gila, reckoned from the S. round by W.

$Z'' =$ azimuth at the initial point $\qquad \sigma =$ distance in arc.

$$\tan.\ l' = \frac{b}{a}\tan.\ L' \qquad \tan.\ l'' = \frac{b}{a}\tan.\ L''$$

In the spherical triangle formed by l', l'', and P, we now compute the angles $180° - Z'$ and $Z'' - 180°$, the arc σ, and also l, = the latitude of the foot of the perpendicular from the pole, and obtain for a first approximation:

$$Z' = 85°\ 33'\ 25''.05 \qquad \sigma = 7739''.75$$

$$Z'' - 180° = 84°\ 11'\ 25''.21 \qquad l = 32°\ 54'\ 22''.69$$

Next we compute the correction $d\,P$, to be applied to the spheroidal difference of longitude P, by the formula

$$d\,P = -\sigma\,(\tfrac{1}{2}\,e - \tfrac{3}{8}\,e^2)\ \cos.\ l = +\ 21''.72$$

And we get................ $P + d\,P = 2^\circ\ 32'\ 46''.62$

Substituting this into the former computation, we obtain

$Z' = 85^\circ\ 34'\ 14''.41$ $\qquad \sigma = 7758''.10$

$Z'' - 180^\circ = 84^\circ\ 12'\ 02''.89$ $\qquad l = 32^\circ\ 54'\ 16''.71$

And by a second substitution of the latter values we obtain, finally,

$Z' = 85^\circ\ 34'\ 14''.49$ $\qquad d\,P = +\ 21''.77$

$Z'' - 180^\circ = 84^\circ\ 12'\ 02''.95$ $\qquad \sigma = 7758''.15$

We also compute σ' and σ'', the arcs from l' and l'' to the foot of the perpendicular l, viz: $\sigma' = 6^\circ\ 52'\ 31''.5$; $\sigma'' = 9^\circ\ 01'\ 49''.7$; and obtain the distance s in metres by the expression

$$\frac{s}{b} = \sigma\,(1 + \tfrac{1}{4}\,e\ \sin.^2 l - \tfrac{3}{64}\,e^2\ \sin.^4 l) + (\sin.\ 2\,\sigma'' - \sin.\ 2\,\sigma')\,(\tfrac{1}{8}\,e\ \sin.^2 l - \tfrac{1}{32}\,e^2\ \sin.^4 l) - \cdots$$

1st term	$= +$	239187.0
2d term................	$= +$	113.8
3d term................	$= -$	0.0
Distance s............	$=$	239300.8 metres = 261692.0 yards = 148.689 miles.

Azimuth at initial point on Pacific coast	$= 84^\circ\ 12'\ 02''.95$
Azimuth at junction of Gila and Colorado..	$= 85^\circ\ 34'\ 14''.49$
Length of line of boundary connecting above points............................	= 148.689 miles

B.

Determinations of boundary line from the Rio Colorado of the west, to the intersection of the 111*th meridian of longitude, west of Greenwich, and parallel* 31° 20′ *north latitude: By Lieutenant N. Michler, Topographical Engineers U. S. A.*

I.—Azimuth line—astronomical positions.

The longitude of the initial point on the Rio Colorado, twenty English miles below its junction with the Gila, as agreed upon by Lieutenant N. Michler, Topographical Engineers United States Army, on the part of the United States, and Francisco Jimenez, first engineer of the Mexican commission, on the part of Mexico, was determined to be 114° 48′ 44.53″ west of Greenwich.

This result was obtained by transferring the longitude of the monument near the junction to the initial point, by Lieutenant Michler's triangulation of the "twenty English miles," the longitude of said monument having been previously obtained from observations by Lieutenant A. W. Whipple, Topographical Engineers, Assistant United States Boundary Survey, deduced from corresponding observations at Greenwich.

	° ′ ″	
Longitude of the monument	114 36 22.20	W. of Greenwich.
Difference of longitude between monument and initial point	+ 12 22.33	
Longitude of initial point	114 48 44.53	

	° ′ ″	
The latitude of the initial point on the Rio Colorado was found to be...	32 29 44.45	North.

This latitude was obtained by a mean of results from observations with zenith telescopes by Lieutenant Michler and Señor Jimenez, at their respective observatories near the initial point, (reduced to Lieutenant Michler's observatory,) as follows:

	° ′ ″	
Determination by Señor Jimenez	32 29 41.53	
Determination by Lieutenant Michler	32 29 41.77	
Mean latitude	32 29 41.65	North.

This latitude of the observatory was then transferred to the initial point, by triangulation, by Lieutenant Michler. By transferring the latitude of the monument near the junction to the same observatory, by two different triangulations, one by Lieutenant Michler and the other by Señor A. Diaz, second engineer Mexican commission, the following were the results:

	° ′ ″	
Known latitude of the monument near the junction	32 43 31.58	North.
Difference of latitude between monument and observatory, by Lieutenant Michler's triangulation	— 13 48.95	
Latitude of observatory	32 29 42.63	North.
Known latitude of the monument near the junction	32 43 31.58	North.
Difference of latitude between monument and observatory, by Señor Diaz's triangulation	— 13 48.39	
Latitude of observatory	32 29 43.19	North.
	32 29 42.63	"
Difference	00.56	

The azimuth of the line from the junction of the Colorado and Gila, to Lieutenant Michler's observatory, is, at the latter point, 36° 14′ 10″ northeast, and its length 104024.34 feet.

The azimuth of the boundary line from the initial point on the Colorado to the intersection of the 111th meridian, west of Greenwich, and the parallel of 31° 20′ north latitude, is at the initial point 71° 20′ 43″.8 southeast, and at the point of intersection of parallel and meridian 69° 19′ 45″.94 northwest; the length of this line = 382844.87 metres, = 418684.3 yards, = 237.63565 English miles.

Monument No. II, made of cast-iron plates, and pyramidal in form, was placed on the edge of the desert, at a distance from the initial point of 4522.9 yards; its latitude was computed to be 32° 29′ 01″.48 north; its longitude 114° 46′ 14″.43 west of Greenwich. The azimuth of the boundary line at this point was computed to be 71° 19′ 23″.18 southeast.

The longitude of the observatory of the Mexican commission at Quitobaquita, near monuments VII and VIII, as determined by Señor Jimenez, first engineer, from ten lunar culminations, commencing July 23, 1856, and ending August 2, 1856, inclusive, was found to be 112° 52′ 25″.73 (*7h. 31m. 29.775s.*) west of Greenwich.

The latitude of observatory at Quitobaquita, as determined by Señor Jimenez, first engineer, from forty observations upon eight pairs of stars with zenith telescope, was found to be 31° 56′ 26″.57 north.

II.—*Results of calculations of geodetic latitudes and longitudes of points of triangulation of a line "twenty English miles in length," extending from the Monument, near the junction of the Gila and Colorado, to the Initial Point of the new azimuth line. Triangulation by Lieut. N. Michler, Topographical Engineers U. S. A. Computer, John O'Donoghue. Instrument, Bruner Theodolite.*

Name of station.	Letter of station.	Name of side.	Name of angle.	Azimuth.	Angle of station.	Length of sides in feet.	Difference of latitude + north.	Difference of latitude — south.	Difference of longitude + west.	Difference of longitude — east.	Latitude of station.	Longitude of station.
				° ′ ″	° ′ ″		′ ″	′ ″	′ ″	′ ″	° ′ ″	° ′ ″
Monument	M	M C	....	10 13 15.7 S.W.	....	4,921.16	....	— 0 47.9230	+ 0 10.2223	....	32 43 31.6	114 36 22.90
Sierra Prieta	C	C H	F C H	21 40 37 S.E.	156 53 9	22,988.95	....	— 3 31.4058	....	— 1 30.3261	32 12 43.677	114 36 32.4223
East stations	H	H K	C H K	48 3 25 S.W.	110 16 51.5	19,247.3	....	— 2 7.3320	+ 2 47.3941	....	32 30 12.2712	114 34 53.0064
	K	K Q	H K Q	20 20 39 S.W.	207 32 15.6	6,603.97	....	— 1 1.2414	+ 0 27.0490	....	32 37 4.2392	114 37 40.4903
	Q	Q R	K Q R	67 16 26 S.W.	133 12 58.8	4,030.91	....	— 0 15.4117	+ 0 43.4691	....	32 36 3.6978	114 38 7.5223
	R′	R W	Q R W	2 3 12 S.E.	249 19 14.7	7,161.32	....	— 1 10.8910	....	— 0 2.9990	32 35 48.2861	114 38 50.0044
	W	W V	R W V	32 28 8 S.W.	145 28 41.4	6,825.19	....	— 0 56.9812	+ 0 42.8146	....	32 31 37.4651	114 38 47.9954
	V	V X′	W V X′	32 2 22 S.W.	180 25 23	5,400.98	....	— 0 32.7900	+ 0 33.8478	....	32 33 40.4839	114 39 30.8100
	X′	X′ Y′	V X′ Y′	56 56 59 S.W.	155 5 11.5	2,459.80	....	— 0 13.2763	+ 0 24.0835	....	32 33 7.7639	114 40 4.0578
	Y′	Y′ Z′	X′ Y′ Z′	37 44 30 S.W.	199 12 8.8	9,677.29	....	— 1 15.7318	+ 1 9.1879	....	32 32 54.4876	114 40 28.7413
	Z′	Z′ B′	Y′ Z′ B′	25 35 37 S.W.	192 8 16.3	14,028.38	....	— 2 5.2035	+ 1 10.7553	....	32 31 38.7558	114 41 37.9292
	B′	B′ D′	Z′ B′ D′	78 20 51 S.W.	197 5 7.9	16,530.94	....	— 0 45.7492	+ 3 9.1156	....	32 29 33.5523	114 42 48.0845
	D′	D′ F′	B′ D′ F′	63 50 36 S.W.	142 17 35	12,568.51	+ 0 54.8439	....	+ 2 11.7016	....	32 28 47.8031	114 45 57.8003
Observatory near initial point, on Colorado	F′	....	....	....	....	....	....	....	....	....	32 29 42.6470	114 48 9.5019
Monument	M	M F	....	15 59 42.8 N.W.	....	2,513.09	+ 0 23.9047	....	+ 0 8.1074	....	32 43 31.6	114 36 22.20
Flag Staff (Fort Yuma)	F	F P	P F G	83 55 37 S.W.	99 55 25.4	33,944.60	....	— 0 35.7091	+ 6 35.1297	....	32 43 55.5047	114 36 30.3074
Pilot Knob	P	G P	F P G	51 11 20 S.E.	44 56 36.7	33,808.90	....	— 3 29.7844	....	— 5 8.1915	32 43 19.7956	114 43 5.4371
West stations	G	G L	P G L	18 22 1 S.W.	249 30 34.7	19,223.95	....	— 3 0.5360	+ 1 10.8218	....	32 39 50.0112	114 37 57.2456
	L	L S	G L S	43 30 0 S.W.	205 8 37.2	4,216 71	....	— 0 30.2684	+ 0 33.2338	....	32 36 49.4752	114 39 8.0674
	S	Q T	L S T	8 55 17 S.W.	145 25 35.6	9,492.13	....	— 1 32.7926	+ 0 17.2045	....	32 36 19.2068	114 39 42.0012
	T	T W	S T W	20 11 14 S.W.	191 16 6.2	10,055.98	....	— 1 33.3977	+ 0 40.5468	....	32 34 46.4142	114 39 59.2057
	W	W Z	T W Z	57 49 27 S.W.	217 38 34.5	9,572.11	....	— 0 50.4506	+ 1 34.6498	....	32 33 13.0165	114 40 39.7523
	Z	Z A′	W Z A′	37 13 59 S.W.	159 24 23.3	10,754.1	....	— 1 31.7140	+ 1 22.2532	....	32 32 22.5659	114 42 14.4021
	A′	A′ C′	Z A′ C′	69 25 20 S.W.	212 12 5	15,339.12	....	— 0 53.3885	+ 2 47.6849	....	32 30 50.8519	114 43 36.6553
	C′	C′ F″	A′ C′ F″	80 33 0 S.W.	191 9 10	9,131.91	....	— 0 14.8490	+ 1 45.1849	....	32 29 57.4634	114 46 24.3402
Observatory near initial point, on Colorado	F″	....	....	....	....	....	....	....	....	....	32 29 42.6144	114 48 9.5224
First determination by east stations of triangles											32 29 42.6470	114 48 09.5019
Second determination by west stations of triangles											32 29 42.6144	114 48 09.5224
											85.2614	19.0243
Mean latitude and longitude of observatory near initial point											32 29 42.6307	114 48 09.519

"The base line of the triangulation of the twenty English miles to a point on the Colorado from its junction with the Gila," was measured by Lieut. N. Michler, corps topographical engineers, with two iron rods, "A" and "B," corresponding with rod "B," in the possession of Mr. R. D. Cutts, U. S. Coast Survey, the length of which is 4.0002457 metres at 32° Fahrenheit. The length of one metre, at 32° Fahrenheit, is equal to 39.3685034 inches at 62° Fahrenheit of the standard made by Troughton.

Rate of expansion of rods for 1° Fahrenheit, .000006963535.

The total length of the base, as computed by John O'Donoghue, computer, is 5,867 feet 5.9 inches.

Table showing the length of rods, at different temperatures, of the American and English Imperial Standard.

Temperature of iron rods.	Length of rods at this temperature, of American standard.	Length of rods at this temperat'e, of the English imperial standard.	Temperature of iron rods.	Length of rods at this temperature, of American standard.	Length of rods at this temperat'e, of the English imperial standard.
°	*Inches.*	*Inches.*	°	*Inches.*	*Inches.*
52	157.5056195	157.512060	62	157.5165855	157.523070
53	.5067161	.513161	63	.5176821	.524171
54	.5078127	.514262	64	.5187787	.525272
55	.5089093	.515363	65	.5198753	.526373
56	.5100059	.516464	66	.5209719	.527474
57	.5111025	.517565	67	.5220685	.528575
58	.5121991	.518666	68	.5231651	.529676
59	.5132957	.519767	69	.5242617	.530777
60	.5143923	.520868	70	.5253583	.531878
61	.5154889	.521969			

Table showing the quantity to be taken from the length of the measuring-rod at the different elevations.

Angle of elevation.	Sum to be subtracted from the length of the rod.	Angle of elevations.	Sum to be subtracted from the length of the rod.
° ′	*Inches.*	° ′	*Inches.*
0 00	0.0000000	0 35	0.0081595
0 05	0.0001733	0 40	0.0106641
0 10	0.0006615	0 45	0.0134995
0 15	0.0014964	0 50	0.0166656
0 20	0.0026612	0 55	0.0201626
0 25	0.0041585	1 00	0.0239903
0 30	0.0061275		

The point "F′" was Lieut. Michler's observatory, and distant from the junction of the Colorado and Gila, in a straight line, 104024.34 feet; the azimuth of this line, at the point "F′," is 36° 14′ 10″ N. E., and its length is 1575.66 feet short of twenty miles. (See results of calculations of geodetic latitudes and longitudes of points of triangulation, &c.)

The latitude of point "F′," as obtained from triangulation, is 32° 29′ 42″.64 N., and longitude 114° 48′ 09″.51 west of Greenwich. The latitude used, however, is that obtained from observations with zenith telescope, and is 32° 29′ 41″.65 N.; but the longitude taken is that obtained by triangulation.

The initial point, in the middle of the Colorado, was determined by prolonging the line from the junction, passing through "F′" 1575.66 feet, measured with the two iron rods, "A" and

"B," thus laying off a radius of twenty miles. At the extremity of this line, a perpendicular was erected, or, in other words, a tangent was drawn to the circumference of a circle with that radius and the junction as a centre, and, by means of the following table, the circle was described.

Co-ordinates of points of the circle.

Abscissas in feet, measured along the tangent.	Corresponding ordinates, in feet, measured on perpendiculars to the tangent.	Abscissas in feet, measured along the tangent.	Corresponding ordinates, in feet, measured on perpendiculars to the tangent.
Feet.		*Feet.*	
0 =	0.00	1,300 =	8.29
100 =	0.04745	1,400 =	9.30
200 =	0.19	1,500 =	10.67
300 =	0.427	1,600 =	12.148
400 =	0.759	1,800 =	15.37
500 =	1.186	2,000 =	18.90
600 =	1.708	2,200 =	22.96
700 =	2.325	2,400 =	27.33
800 =	3.037	2,600 =	33.00
900 =	3.843	3,000 =	42.66
1,000 =	4.74	5,000 =	118.10
1,100 =	5.74	10,000 =	472.2
1,200 =	6.83		

A table to lay out on the ground a portion of the circumference of a circle whose radius is twenty miles.

First take a point twenty miles from the mouth of the Gila, and having the direction of the line joining this point and the mouth of the Gila, protract a straight line, making an angle of 88° 34′ 02″.8522 with this line; or prolong a line that will make an angle of 1° 25′ 57″.1478 with the tangent to the circle at the point; then run 5,280 feet on this line, and this will give you a second point on the circle; then place your instrument alternately at the second and first points, and lay off the following angles with this chord of a mile long, and their intersections will be so many points in the circumference of the circle.

	First point.	Second point.	Intermediate points of circumference.
	° ′ ″	° ′ ″	
1	0 06 36.70	1 19 20.44	1st.
2	0 13 13.41	1 12 43.74	2d.
3	0 19 50.11	1 6 7.03	3d.
4	0 26 26.81	0 59 30.33	4th.
5	0 33 3.52	0 52 53.63	5th.
6	0 39 40.22	0 46 16.92	6th.

Having come to a point more than half way, reverse the readings, and they will give you other points commencing near the second point. The greatest distance of the periphery from this chord is about thirty-three feet.

III.—*Tabulation of results for the latitude of astronomical station at the Initial Point on the Rio Colorado, twenty English miles below its junction with the Gila, derived from observations made with zenith telescope of Wurdemann, on sixteen pairs of stars. Observer, Lieut. N. Michler, Corps Topographical Engineers, U. S. Army. Computer, John O'Donoghue.*

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.	8th pair.	9th pair.
	N. 582 G. C. S. 560 G. C.	N. 705 S. 713	N. 791 S. 793	N. 796 S. 804	N. 796 S. 805	N. 812 S. 833	N. 850 S. 845	N. 859 S. 864	N. 924 S. 934
1855.	° ′ ″	° ′ ″	° ′ ′	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
March 17......	....	32 29 37.16	....	32 29 38.63	32 29 36.77	32 29 41.21	....	....	....
18......	32 29 40.96	42.06	....	41.11	38.60	....	32 29 38.71	....	....
April 2.....	....	....	32 29 45.94	....	....	42.14	....	32 29 38.24	....
3......	....	48 57	....	40.45	37.97	....	45.68	....	....
4......	....	....	....	....	48.87	....	44.05	....	....
5......	....	47.68	....	38.34	....	41.23	39.80	....	32 29 36.37
6......	....	....	....	42.64	40.13	....	44.12	40.00	44.96
Lat. by a mean of each pair..	32 29 40.96	32 29 43.87	32 29 45.94	32 29 40.23	32 29 40.47	32 29 41.53	32 29 42.47	32 29 39.12	32 29 40.67

Tabulation of results—Continued.

Date.	10th pair.	11th pair.	12th pair.	13th pair.	14th pair.	15th pair.	16th pair.	1st result.	Final result.
	N. 1010 S. 1012	N. 1044 S. 1026	N. 1044 S. 1046	N. 1062 S. 1089	N. 1063 S. 1089	N. 1064 S. 1089	N. 1157 S. 1175	Latitude by a mean of all the pairs.	
1855.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
March 17......	....	....	....	....	....	....	....	....	....
18......	....	....	....	....	....	....	....	....	....
April 2......	....	32 29 38.25	....	....	....	....	32 29 46.74	....	....
3......	....	40.80	32 29 38.90	....	....	....	....	....	....
4.....	32 29 47.32	39.80	....	....	....	....	....	....	....
5......	....	....	....	....	....	....	....	....	....
6......	....	....	38.55	32 29 40.04	32 29 41.19	32 29 39.45	....	....	....
Lat. by a mean of each pair..	32 29 47.32	32 29 39.62	32 29 38.73	32 29 40.04	32 29 41.19	32 29 39.45	32 29 46.74	32 29 41.77	32 29 41.77

REMARKS.—The zenith telescope suffered very material injury in its transportation, in consequence of the counterpoise having been separated from the instrument by the breaking of a screw, and knocked about among the other parts. The tangent screws were mostly bent, the micrometer slightly injured, and the spider lines and levels all broken. Being in a country where the levels could not be replaced, the not very sensitive ones of a large bronze theodolite had to be substituted for those broken, and the other injuries repaired by such means as were at hand.

Computations from observations on Polaris, western elongation, for the determination of the value of one division of the micrometer attached to zenith telescope, by Wurdemann, for the U. S. Boundary Commission. March 23, 1855.

No.	Micrometer readings.	Times of observ'n by chron'r.	Time from elongation.	Correct'n for H.	Reduced time.	Nos.	Difference of time.	Difference of time in arc.	Reduction to the equator.	Diff. of micrometer readings.	Resulting values of one division.
		h. m. s.	m.	s.	h. m. s.		m. s.	° ′ ″	′ ″		″
1	300	6 15 48.0	20.91	1.8	6 15 49.8	1 to 6	8 29.7	2 7 25.5	3 15.0	300	0.65000
2	250	17 12.0	19.52	1.4	17 13.4	5	7 6.2	1 46 33.0	2 43.1	250	0.65200
3	150	20 5.8	16.62	0.9	20 6.7	4	5 42.4	1 25 36.0	2 11.0	150	0.65500
4	100	21 31.5	15.19	0.7	21 32.2	3	4 16.9	1 4 13.5	1 38.3	100	0.65500
5	50	22 55.5	13.79	0.5	22 56.0	2	1 23.6	20 54.0	32.0	50	0.64000
6	00	24 19.2	12.40	0.3	24 19.5	2 to 6	7 6.1	1 46 31.5	2 43.0	250	0.65280
7	100	27 9.2	9.56	0.1	27 9.3	6 to 14	16 44.7	4 11 10.5	6 25.1	600	0.64183
8	150	28 34.0	8.10	0.1	28 34.1	13	15 20.5	3 50 7.5	5 51.9	550	0.63982
9	250	31 20.0	5.38	0.0	31 20.0	12	13 59.5	3 29 52.5	5 21.0	500	0.64200
10	350	34 11.0	2.53	0.0	34 11.0	11	12 35.5	3 8 52.5	4 49.0	450	0.64222
11	450	36 55.0	0.18	0.0	36 55.0	10	9 51.5	2 27 52.5	3 46.2	350	0.64639
12	500	38 19.0	1.59	0.0	38 19.0	9	7 0.5	1 45 7.5	2 41.1	250	0.64440
13	550	39 40.0	2.94	0.0	39 40.0	8	4 14.6	1 3 39.0	1 37.4	150	0.64933
14	600	41 4.2	4.34	0.0	41 4.2	7 to 14	13 54.9	3 28 43.5	5 19.3	500	0.63860

Mean $= \frac{9.04939}{14} = 0''.64638$ by 1st series. Sum $= 9.04939$

Remarks.

Chronometer slow .... = 28m. [illegible]
Time, by chronometer, of western elongation of Polaris .... = 6h. 36m. 43s.350
Declination of star .... = 88° 32′ 17″.4

Observer, Lieut. N. Michler, Top. Engineers, U. S. A. Computer, Hugh Campbell.

Computations for the value of one division of the micrometer, &c.—Continued.

No.	Micrometer readings.	Time of observ'n by mic'ter.	Time from elongation.	Correct'n for H.	Reduced time.	Nos.	Difference of time.	Difference of time in arc.	Reduction to the equator.	Diff. of micrometer readings.	Value of one divis'n of the micrometer.
		h. m. s.	m.	s.	h. m. s.		m. s.	° ′ ″	′ ″		″
1	300	6 15 48.0	20.91	1.8	6 15 49.8	7 to 13	13 54.9	3 7 40.5	4 47.1	450	0.63800
2	250	17 12.0	19.52	1.4	17 13.4	12	12 30.7	2 47 25.5	4 16.1	400	0.64025
3	150	20 5.8	16.62	0.9	20 6.7	11	11 9.7	2 26 25.5	3 44.0	350	0.64000
4	100	21 31.5	15.19	0.7	21 32.2	10	9 45.7	1 45 25.5	2 41.4	250	0.64560
5	50	22 55 5	13.79	0.5	22 56.0	8 to 14	12 30.1	3 7 31.5	4 46.9	450	0.63533
6	0	24 19.2	12.40	0.3	24 19.5	13	11 5.9	2 46 28.5	4 14.7	400	0.63675
7	100	27 9.2	9.56	0.1	27 9.3	12	9 44.9	2 26 13.5	3 43.7	350	0.63914
8	150	28 34.0	8.10	0.1	28 34.1	11	8 20.9	2 5 13.5	3 11.6	300	0.63866
9	250	31 20.0	5.38	0.0	31 20.0	14 to 1	25 14.4	6 18 36.0	9 38.3	900	0.64255
10	350	34 11.0	2.53	0.0	34 11.0	13 to 2	22 26.6	5 36 39.0	8 34.4	800	0.64300
11	450	36 55.0	0.18	0.0	36 55.0	12 to 3	18 12.3	4 33 4.5	6 57.5	650	0.64230
12	500	38 19.0	1.59	0.0	38 19.0	11 to 4	15 22.8	3 50 42.0	5 52.8	550	0.63600
13	550	39 40.0	2.94	0.0	39 40.0	14 to 2	23 50.8	5 57 42.0	9 6.5	850	0.64294
14	600	41 4.2	4.34	0.0	41 4.2	13 to 3	19 33.3	4 53 19.5	7 28.4	700	0.64066

Mean $= \frac{8.96018}{14} = 0''.64001$ by 2d series. Sum $= 8.96018$

1st series .... = 0″.64638
2d series .... = 0.64001
Mean .... = 0.643195

1st sum .... = 9.04939
2d sum .... = 8.96018

$\frac{18.00957}{28} = 0''.643198$ = mean of 28 combinations.

1st mean .... = 0″.643195
2d mean .... = 0.643198
Result by Polaris .... = 0.643196

Observer, Lieut. N. Michler, Top. Engineers, U. S. A. Computer, Hugh Campbell.

Computations from observations on δ Ursæ Minoris, eastern elongation, for the value of one division of the micrometer. March 23, 1855.

No.	Micrometer readings.	Time of observat'n by chron'r.	Time from elongation.	Correct'n for H.	Reduced time.	No.	Micrometer readings.	Time of observat'n by chronometer.	Time from elongation	Correct'n for H.	Reduced time.
		h. m. s.	m.	s.	h. m. s.			h. m. s.	m.	s.	h. m. s.
1	400	11 46 25.0	3.9	0.0	11 46 25.0	19	1000	12 03 06.0	12.7	0.4	12 03 05.4
2	350	46 59.5	3.4	0.0	46 59.9	20	1050	03 40.5	13.1	0.4	03 40.1
3	300	47 36.5	2.8	0.0	47 36.5	21	1100	04 15.8	13.9	0.5	04 15.3
4	250	48 13.5	2.1	0.0	48 13.5	22	1150	04 52.5	14.4	0.6	04 51.9
5	200	48 50.0	1.5	0.0	48 50.0	23	1250	06 04.0	15.6	0.7	06 03.3
6	150	49 23.0	1.0	0.0	49 23.0	24	1300	06 40.8	16.3	0.8	06 40.0
7	100	49 58.8	0.4	0.0	49 58.8	25	1350	07 16.0	16.8	0.9	07 15.1
8	50	50 35.0	0.2	0.0	50 35.0	26	1400	07 51.6	17.4	1.0	07 50.6
9	0	51 08.5	0.7	0.0	51 08.5	27	1500	08 58.0	18.5	1.2	08 56.8
10	50	51 43.0	1.3	0.0	51 43.0	28	1550	09 33.0	19.1	1.3	09 31.7
11	100	52 19.0	1.9	0.0	52 19.0	29	1600	10 08.0	19.7	1.4	10 06.6
12	300	54 46.0	4.3	0.0	54 46.0	30	1700	11 21.8	20.9	1.8	11 20.0
13	350	55 19.0	4.9	0.0	55 19.0	31	1800	12 31.5	22.1	2.0	12 29.5
14	450	56 32.0	6.0	0.0	56 32.0	32	1850	13 07.0	22.7	2.3	13 04.7
15	550	57 45.0	7.3	0.0	57 45.0	33	1900	13 44.5	23.3	2.3	13 42.2
16	750	12 00 04.5	9.6	0.1	12 00 04.4	34	1950	14 19.6	23.9	2.6	14 17.0
17	850	01 17.0	10.9	0.2	01 16.8	35	2000	14 57.0	24.5	2.8	14 54.0
18	900	01 51.6	11.4	0.2	01 51.4						

Remarks.

Time by chronometer of eastern elongation of δ Ursæ Minoris........................ 11h. 50m. 24s.760
Chronometer slow.. = 28m. 41s.49
Declination of star... = 86° 35′ 32″.5.

Combination of results for the determination of one division of the micrometer, derived from observations on δ Ursæ Minoris near eastern elongation.

Nos.	Microm'er divisions.	Differences of times.	Differences of times in arc.	Reduction to the equator.	Values of one division.	Nos.	Microm'er divisions.	Differences of times.	Differences of times in arc.	Reduction to the equator.	Values of one div'n.
		m. s.	° ′ ″	′ ″	″			m. s.	° ′ ″	′ ″	″
1 to 18	1300	15 26.4	3 51 36.0	13 45.3	.63484	1 to 35	2400	28 29.2	7 07 18.0	25 20.0	.63333
2 to 19	1350	16 05.9	4 01 28.5	14 20.5	.63888	2 to 34	2300	27 17.5	6 49 22.5	24 16.5	.63317
3 to 20	1350	16 03.6	4 00 54.0	14 18.4	.63585	3 to 33	2200	26 08.0	6 32 00.0	23 15.0	.63409
4 to 21	1350	16 01.8	4 00 27.0	14 17.8	.63547	4 to 32	2100	24 53.5	6 13 22.5	22 09.0	.63285
5 to 22	1350	16 01.9	4 00 28.5	14 16.9	.63474	5 to 31	2000	23 39.5	5 54 52.5	21 03.3	.63165
6 to 23	1400	16 40.3	4 10 04.5	14 51.0	.63642	6 to 30	1850	21 57.0	5 29 15.0	19 32.4	.63373
7 to 24	1400	16 41.2	4 10 18.0	14 51.9	.63771	7 to 29	1700	20 07.8	5 01 57.0	17 55.4	.63288
8 to 25	1400	16 40.1	4 10 01.5	14 50.9	.63635	8 to 28	1600	18 56.7	4 44 10.5	16 52.3	.63269
9 to 26	1400	16 42.1	4 10 31.5	14 52.7	.63764	9 to 27	1500	17 48.3	4 27 04.5	15 51.5	.63433
10 to 27	1450	17 13.8	4 18 27.0	15 20.8	.63503	10 to 26	1350	16 08.6	4 02 09.0	14 22.8	.63911
11 to 28	1450	17 12.7	4 18 10.5	15 19.8	.63433	11 to 25	1250	14 57.0	3 44 15.0	13 19.2	.63935
12 to 29	1300	15 20.6	3 50 09.0	13 40.1	.63077	12 to 24	1000	11 54.8	2 58 42.0	10 37.0	.63700
13 to 30	1350	16 01.0	4 00 15.0	14 16.1	.63474	13 to 23	900	10 45.0	2 41 15.0	9 35.9	.63988
14 to 31	1350	15 57.5	3 59 22.5	14 13.0	.63185						
15 to 32	1300	15 19.7	3 49 55.5	13 39.3	.63023	1st series—mean					0.63492
16 to 33	1100	13 00.3	3 15 04.5	11 36.3	.63300	2d series—mean					0.63466
17 to 34	1100	13 00.2	3 15 03.6	11 35.2	.63200	Result by δ Ursæ Minoris					0.63479
18 to 35	1100	13 02.8	3 15 42.0	11 37.5	.63409	Result by Polaris					0.64319
				Mean =	0.63466	Final result					0.63899

Value of one division of the micrometer from observations on Polaris (western elongation) and δ Ursæ Minoris (eastern elongation) is 0″.63899.

Observer, Lieut. N. Michler, U. S. Topographical Engineers. Computer, Hugh Campbell.

IV.—*Table showing the triangulated distances, in metres and yards, between the different monuments of the survey of that portion of the boundary line running from the Initial Point, on the Colorado river, to the intersection of the parallel 31° 20′ 00″ north latitude, and the meridian 111° 00′ 00″ west of Greenwich.*

Triangulation by Lieut. N. Michler, Mr. A. C. V. Schott, and Señor A. Diaz.

	Metres.	Yards.	Remarks.
From Initial Point, on the Colorado river, to Monument I...	964.62	1054.9214	Monument I, in River bottom, near the bank.
Monument I to Monument II	3171.12	3467.9793	Monument II, Iron monument, on desert.
Monument II to Monument III	829.81	907.4913	Monument III, erected on desert.
Monument III to Monument IV	72170.00	78926.0790	Monument IV, Sierra de las Tinajas Altas.
Monument IV to Monument V	44393.34	48549.1515	Monument V, Sierra del Tule.
Monument V to Monument VI	57633.12	63028.3523	Monument VI, Sierra del Agua Dulce.
Monument VI to Monument VII	13203.04	14439.0215	Monument VII, near Rancho de Quitobaquita.
Monument VII to Monument VIII	877.61	959.7660	Monument VIII, near Rancho de Quitobaquita.
Monument VIII to Monument IX	17298.65	18918.0354	Monument IX, Sierra de Sonoyta.
Monument IX to Monument X	23405.35	25596.4044	Monument X, west ridge of Sierra de la Nariz.
Monument X to Monument XI	4180.00	4571.3040	Monument XI, on the wagon road from Cobota to So-noyta.
Monument XI to Monument XII	2793.97	3055.5230	Monument XII, east ridge of Sierra de la Nariz.
Monument XII to Monument XIII	44698.76	48883.1629	Monument XIII, on the road from Tubac to Cobota.
Monument XIII to Monument XIV	18986.27	20763.6403	Monument XIV, Sierra de la Union.
Monument XIV to Monument XV	26493.60	28973.7560	Monument XV, Sierra del Pozo Verde.
Monument XV to Monument XVI	14592.57	15958.6301	Monument XVI, near Ojos de los Granizos.
Monument XVI to Monument XVII	3519.11	3848.5458	Monument XVII, Sierra de Sonora.
Monument XVII to Monument XVIII	27962.77	30580.4599	Monument XVIII, Sierra de los Pajaritos.
Monument XVIII to Monument XIX	5261.97	5754 5609	Monument XIX, Sierra de los Pajaritos.
Monument XIX to intersection of parallel 31° 20′ N. latitude, and meridian 111° west of Greenwich..	409.19	447.4957	Monument (intersection of meridian and parallel) Sierra de los Pajaritos.
Total length of line	382844.87	418684.2807	

C.

Astronomical observations for establishing the 111th meridian of longitude west of Greenwich, and for determining the parallels 31° 47′ and 31° 20′ north latitude: By John H. Clark.

The four manuscript volumes which have been submitted to the U. S. Commissioner, embrace a complete tabulation of all the observations, both for latitude and longitude, made along the parallels of 31° 47′ and 31° 20′. It will be seen, by a reference to these volumes, that each of the stations has been determined in latitude with a zenith telescope, (T. & S.,) by about one hundred observations, and two in longitude, with a transit of thirty-six inches focal length, by observations on the moon and moon culminating stars.

In accordance with the direction of the Commissioner, the stars for latitude were at first selected exclusively from the Greenwich Twelve-year catalogue. At Espia, however, it was found that this catalogue no longer afforded, in that portion of the heavens then observable, a sufficient number of pairs that would fulfil the conditions required for satisfactory results. It was therefore deemed expedient, in the exigencies of the survey, to rely subsequently almost wholly upon the British Association catalogue.

It was found, by combining the results of observations on about thirty pairs of stars taken from this catalogue, that any error in the final result arising from errors of polar distances was materially reduced; and although, by comparing the means of the observations on each pair, there seemed to be in some cases errors of polar distances developed, all the results were nevertheless incorporated to obtain the one adopted; nor was a single observation rejected because of its apparent inconsistency or want of parallelism with any previous or subsequent result obtained by it or by any other pair, except at one station, (Agua del Perro,) where the instrument was mounted on a rock, (no timber being attainable,) and the observations otherwise rendered objectionable by the violence of the wind. Thus the result of every pair, whether high or low, and without reference to the "general run," has been included in the "means" used to obtain the latitude adopted.

A subsequent and careful revision in the office of the computations made in the field has disclosed no considerable error.

A brief summary of the observations and results of all the stations, and a reference to the tables which are appended, are here given:

1. The observations at Los Nogales for determining the 111th degree of longitude west of Greenwich, extending through two lunations, and computed from data furnished by the Nautical Almanac, gave the result as shown by Table I, 110° 51′ 01″.95, (7^h 23^m $24^s.13$). The latitude deduced from 120 observations on 29 pairs of stars, taken from the British Association catalogue, is (see Table II) 31° 21′ 00″.48.

2. Seventy-three observations on 23 pairs of stars, selected from British Association catalogue, give for the latitude of the station near the head of Rio Santa Cruz, (Table III) 31° 17′ 56″.33.

3. At San Bernardino there were 57 observations on 21 pairs from British Association catalogue, and the latitude deduced therefrom, (Table IV,) 31° 19′ 40″.38.

4. The result deduced from 97 observations on 28 pairs of stars gives for the latitude of San Luis spring (Table V) 31° 20′ 31″.51.

5. At Agua del Perro there were 81 observations on 25 pairs of stars selected from both cata-

logues, (British Association catalogue and Greenwich catalogue,) and the latitude deduced, (Table VI,) 31° 20′ 57″.56.

6. The observations at Espia, made on 23 pairs of stars, partly from the Greenwich Twelve-year catalogue and partly from the British Association catalogue, amount to 81, and give for the latitude (Table VII) 31° 20′ 56″.45.

7. The latitude of Carrizalillo, resulting from 72 observations on 14 pairs of stars, selected entirely from the Greenwich Twelve-year catalogue, is (Table VIII) 31° 50′ 55″.23; longitude, (Table IX) $7^h\ 11^m\ 44^s.26 = 107° 56′ 03″.9$.

8. The result for the initial point on the Rio Grande, obtained from 108 observations on 22 pairs of stars, selected also exclusively from the Greenwich Twelve-year catalogue, is (Table X) 31° 46′ 51″.29.

TABLE I.

Results for longitude of astronomical station at Las Nogales, east of the intersection of the 111*th degree of longitude and the parallel of* 31° 20′ *north latitude.*

Date.	Authority for elements used.	Results for moon's 1st limb.	Date.	Authority for elements used.	Results for moon's 2d limb.	Date.	Authority for elements used.	Results for moon's 1st limb.	Date.	Authority for elements used.	Results for moon's 2d limb.
1855.		h. m. s.	1855.		h. m. s.	1855.		h. m. s.	1855.		h. m. s.
May 24	N. A. A. Rs.	7 23 19.20	May 30	N. A. A. Rs.	7 23 23.24	June 22	N. A. A. Rs.	7 23 42.93	June 28	N. A. A. Rs.	7 23 16.76
25	......do......	20.41	31	......do......	26.71	28	......do......	15.88	30	......do......	17.14
26	......do......	27.92							July 1	......do......	20.78
28	......do......	32.87									
29	......do	25.78									
Mean longitude from moon's 1st limb.............7h. 23m. 25.24s.			Mean longitude from moon's 2d limb. ....7h. 23m. 24.97s. Mean longitude from moon's 1st limb............7h. 23m. 25.24s.			Mean longitude from moon's 1st limb..............7h. 23m. 29.40s.			Mean longitude from moon's 2d limb.............7h. 23m. 18.23s. Mean longitude from moon's 1st limb.............7h. 23m. 29.40s.		

	h. m. s.		h. m. s.
Mean longitude from 1st lunation..............................	7 23 25.10	Mean longitude from 2d lunation..............................	7 23 23.81
Mean longitude from 2d lunation..............................	23.81		
Longitude of Station..............................	7 23 24.45		

Date.	Results for longitude during two lunations.	Date.	Results for longitude during two lunations.
1855.	h. m. s.	1855.	h. m. s.
May 24	7 23 19.200	May 31	7 23 26.710
25	7 23 20.410	June 22	7 23 42.930
26	7 23 27.920	28	7 23 15.884
28	7 23 32.870	28	7 23 16.764
29	7 23 25.780	30	7 23 17.140
30	7 23 23.240	July 1	7 23 20.780

Longitude of Los Nogales by a mean of the above results, (the one adopted,) 7*h*. 23*m*. 24.136*s*.

TABLE II.

Tabulation of results for the latitude of astronomical station at Los Nogales derived from observations made with a zenith telescope (T. & S.) on twenty-nine pairs of stars: By J. H. Clark, Principal Assistant.

Date.	1st pair. B. A. C. *S. 3995 †N. 4026	2d pair. B. A. C. S. 3995 N. 4028	3d pair. B. A. C. S. 4110 N. 4026	4th pair. B. A. C. N. 4128 S. 4142	5th pair. B. A. C. S. 4248 N. 4282	6th pair. B. A. C. N. [illegible] S. 4318	7th pair. B. A. C. N. [illegible] S. 4319	8th pair. B. A. C. S. [illegible] N. 4408	9th pair. B. A. C. S. [illegible] N. 4415	10th pair. B. A. C. S. 4388 N. 4595	11th pair. B. A. C. S. 4388 N. 4600	12th pair. B. A. C. N. 4408 S. 4575
1855.	"	"	"	"	"	"	"	"	"	"	"	"
May 23	....	....	....	....	60.45	60.42	....	[illegible]	[illegible]	....	....	....
25	....	....	....	....	....	....	....	....	....	....	....	....
26	....	....	....	....	....	....	....	....	....	....	....	....
29	[illegible]	[illegible]	[illegible]	[illegible]	60.28	60.76	[illegible]	63.33	64.87	[illegible]	[illegible]	59.92
30	[illegible]	[illegible]	64.61	....	58.12	58.96	[illegible]	59.83	61.64	59.05	60.37	59.05
June 5	....	....	....	....	59.35	60.68	60.14	62.74	64.01	62.13	[illegible]	60.43
7	....	....	....	....	59.45	61.59	61.00	62.73	63.38	[illegible]	[illegible]	60.35
Mean of each pair	58.60	59.82	64.78	[illegible]	59.53	60.48	60 33	62.28	63.44	61.61	62.96	59.93

TABLE II—Continued.

Date.	13th pair. B. A. C. N. 4415 S. 4575	14th pair. B. A. C. S. 4575 N. 4595	15th pair. B. A. C. S. 4575 N. 4600	16th pair. B. A. C. N. 4714 S. 4723	17th pair. B. A. C. S. 4737 N. 4741	18th pair. B. A. C. S. 4810 N. 4943	19th pair. B. A. C. N. 4803 S. 4823	20th pair. B. A. C. N. 4961 S. [illegible]	21st pair. B. A. C. S. 5075 N. [illegible]	22d pair. B. A. C. N. 5157 S. 5189	23d pair. B. A. C. N. 5175 S. 5234	24th pair. B. A. C. S. 5244 N. 5259
1855.	"	"	"	"	"	"	"	"	"	"	"	"
May 23	....	60.93	62.66	58.32	59.38	....	59.95	61.21	61.04	56.67	....	61.73
25	....	56.44	57.70	59.07	57.85	....	60.31	62.19	60.14	[illegible]	....	[illegible]
26	....	59.55	60.29	58.42	59.21	....	60.58	62.05	59.01	[illegible]	....	62.22
29	61.38	59.89	61.69	....	....	....	....	....	....	....	....	....
30	60.86	58.78	59.61	60.67	56.66	60.34	....	60.52	....	....	....	....
June 5	61.75	59.86	61.12	60.28	....	....	61.33	62.80	61.43	....	[illegible]	[illegible]
7	61.00	59.51	60.54	59.91	59.38	....	62.23	63.50	62.52	....	[illegible]	[illegible]
Mean of each pair	61.24	59.28	60.51	59.44	58.49	60.34	60.88	62.04	60.82	56.39	59.69	62.11

TABLE II—Continued.

Date.	25th pair. B. A. C. S. 5284 N. 5338	26th pair. B. A. C. S. 5367 N. 5388	27th pair. B. A. C. S. 5368 N. 5388	28th pair. B. A. C. S 5504 N. 5568	29th pair. B. A. C. S. 5507 N. 5568	Latitude by a mean of each night.	1st result. Latitude by a mean of each pair.	2d result. Lat. by a mean of all the observations.	3d result. Lat. by a mean of the results for each night.	Final result. Mean of 1st, 2d, and 3d results.
1855.	"	"	"	"	"	° ′ "	° ′ "	° ′ "	° ′ "	° ′ "
May 23	60.64	59.54	58.97	58.27	59.74	31 20 60.33				
25	58.89	59.68	58 86	58.62	60.10	[illegible]				
26	60.75	59.86	59.63	....	....	[illegible]				
29	....	....	....	....	....	[illegible]				
30	....	....	....	....	....	31 20 59.79				
June 5	61.80	60.97	60.19	59.05	60.19	31 20 61.13				
7	62.38	[illegible]	60.45	....	....	31 20 61.33				
Mean of each pair.	60.83	60.25	59.62	[illegible]	60.01		31 20 60.45	31 20 60.55	31 20 60.45	31 20 60.48

*S., star south of the zenith. †N., star north of the zenith.

TABLE III.

Tabulation of results for the latitude of astronomical station at head of Santa Cruz river, derived from observations made with a zenith telescope (T. & S.) on twenty-three pairs of stars: By J. H. Clark, Principal Assistant, assisted by C. N. Turnbull, Lieut. Corps Top. Eng'rs, U. S. A.

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.	8th pair.	9th pair.	10th pair.
	B. A. C. 3523 S. 3533 N.	B. A. C. 3548 N. 3650 S.	B. A. C. 3742 S. 3811 N.	B. A. C. 3869 S. 3952 N.	B. A. C. 3995 S. 4026 N.	B. A. C. 3995 S. 4028 N.	B. A. C. 4057 N. 4156 S.	B. A. C. 4059 N. 4156 S.	B. A. C. 4177 N. 4242 S.	B. A. C. 4248 S. 4282 N.
1855.	″	″	″	″	″	″	″	″	″	″
May 10	58.28	...	57.59	...	...	...	...	53.19	53.41	...
11	...	53.59	57.23	...	55.72	56.57	52.99	53.16	54.84	56.55
12	...	...	...	56.52	56.76	57.23	...	...	...	...
13	...	...	...	56.09	55.75	57.07	51.81	51.18	55.64	...
14	...	...	...	...	55.39	56.60	52.74	52.00	52.82	54.77
Mean of each pair.	58.28	53.59	57.41	56[illegible]0	55.90	56.86	52.51	52.38	54.19	55.66

TABLE III—Continued.

Date.	11th pair.	12th pair.	13th pair.	14th pair.	15th pair.	16th pair.	17th pair.	18th pair.	19th pair.	20th pair.
	B. A. C. 4282 N. 4318 S.	B. A. C. 4345 N. 4388 S.	B. A. C. 4345 N. 4575 S.	B. A. C. 4346 N. 4388 S.	B. A. C. 4346 N. 4575 S.	B. A. C. 4388 S. 4408 N.	B. A. C. 4388 S. 4415 N.	B. A. C. 4388 S. 4595 N.	B. A. C. 4388 S. 4600 N.	B. A. C. 4408 N. 4575 S.
1855.	″	″	″	″	″	″	″	″	″	″
May 10	57.38	...	...	...	...	58.93	59.49	...	...	...
11	56.47	58.02	56.37	59.38	57.73	57.26	57.00	56.42	56.77	55.58
12	...	56.03	...	56 56	...	...	...	...	...	...
13	55.50	57.59	55.35	58.53	56.32	61.20	60.72	56.90	58.54	57.86
14	57.31	55.96	54.92	56.81	55.73	58.08	58.47	57.95	59.37	57.06
Mean of each pair.	56.66	56.90	55.54	57.82	56.59	58.86	58.92	57.08	58.22	56.83

TABLE III—Continued.

Date.	21st pair.	22d pair.	23d pair.	Latitude by a mean of each night.	1st result.	2d result.	3d result.	Final result.
	B. A. C. 4415 N. 4575 S.	B. A. C. 4575 S. 4595 N.	B. A. C. 4575 S. 4600 N.		Latitude by a mean of each pair.	Latitude by a mean of all the observations.	Latitude by a mean of the results for each night.	Mean of 1st, 2d, and 3d results.
1855.	″	″	″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
May 10	...	53.60	54.74	31 17 56.36				
11	55 26	54.77	55.09	31 17 56.03				
12	...	...	...	31 17 56.62				
13	56.51	54.65	57.55	31 17 56.67				
14	57.46	56.94	58.20	31 17 56.24				
Mean of each pair.	57.07	54.99	56.39		31 17 56.30	31 17 56.32	31 17 56.38	31 17 56.33

TABLE IV.

Tabulation of results for the latitude of astronomical station at San Bernardino, derived from observations made with a zenith telescope (T. & S.) on twenty-one pairs of stars: By J. H. Clark, Principal Assistant, assisted by H. Campbell.

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.	8th pair.	9th pair.
	B. A. C. 3327 S. 3364 N.	B. A. C. 3416 N. 3500 S.	B. A. C. 3523 S. 3533 N.	B. A. C. 3548 N. 3650 S.	B. A. C. 3566 N. 3650 S.	B. A. C. 3742 S. 3811 N.	B. A. C. 3842 S. 3856 N.	B. A. C. 3919 S. 3953 N.	B. A. C. 3953 N. 3992 S.
1855.	″	″	″	″	″	″	″	″	″
April 27.........	40.71	37.16	41.89	40.35	40.52	....	....	40.74	41.51
28.........	40.07	38.01	42.35	....	....	....	....	....	....
29.........	42.09	35.24	....	42.03	40.27	43.05	41.85	41.18	38.99
30.........	38.31	35.52	40.79	....	42.80	40.66	41.04	40.35	....
May 2.........	....	....	....	....	....	40.44	41.37	....	....
Mean of each pair	40.29	36.48	41.67	41.29	41.19	41.38	41.75	40.75	39.25

TABLE IV—Continued.

Date.	10th pair.	11th pair.	12th pair.	13th pair.	14th pair.	15th pair.	16th pair.	17th pair.	18th pair.
	B. A. C. 3995 S. 4026 N.	B. A. C. 3995 S. 4028 N.	B. A. C. 4059 N. 4156 S.	B. A. C. 4177 N. 4242 S.	B. A. C. 4248 S. 4282 N.	B. A. C. 4262 N. 4318 S.	B. A. C. 4262 N. 4319 S.	B. A. C. 4368 S. 4408 N.	B. A. C. 4392 S. 4415 N.
1855.	″	″	″	″	″	″	″	″	″
April 27.........	....	....	....	....	....	....	....	....	....
28.........	....	....	....	....	....	....	....	....	....
29.........	....	....	38.00	38.35	38.77	39.64	39.65	44.03	45.51
30.........	38.25	41.38	35.98	38.18	39.39	39.66	40.27	41.68	43.21
May 2.........	40.87	41.12	41.98	....	40.23	38.18	38.73	41.07	43.45
Mean of each pair	39.56	41.25	38.65	38.26	39.46	39.16	39.55	42.26	44.05

TABLE IV—Continued.

Date.	19th pair.	20th pair.	21st pair.	Latitude by a mean of each night.	1st result.	2d result.	3d result.	Final result.
	B. A. C. 4479 N. 4513 S.	B. A. C. 4575 S. 4595 N.	B. A. C. 4575 S. 4600 N.		Latitude by a mean of each pair.	Latitude by a mean of all the observations.	Latitude by a mean of the results for each night.	Latitude by a mean of 1st, 2d, and 3d results.
1855.	″	″	″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
April 27...............	....	....	....	31 19 40.45				
28...............	....	....	....	31 19 40.14				
29...............	40.69	40.07	42.45	31 19 40.55				
30...............	40.84	39.77	41.50	31 19 39.97				
May 2...............	....	....	....	31 19 40.74				
Mean of each pair....	40.76	39.92	41.97		31 19 40.42	31 19 40.35	31 19 40.37	31 19 40.38

TABLE V.

Tabulation of results for the latitude of astronomical station at San Luis Springs, derived from observations made with a zenith telescope (T. & S.) on twenty-eight pairs of stars: By J. H. Clark, Principal Assistant, assisted by Lieut. Turnbull.

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.	8th pair.	9th pair.	10th pair.	11th pair.	12th pair.
	B. A. C. 3170 S. 3290 N.	B. A. C. 3170 S. 3297 N.	B. A. C. 3204 S. 3290 N	B. A. C. 3204 S. 3297 N.	B. A. C. 3327 S. 3364 N.	B. A. C. 3416 N. 3500 S.	B. A. C. 3523 S. 3533 N.	B. A. C. 3548 N. 3650 S.	B. A. C. 3560 N. 3650 S.	B. A. C. 3742 S. 3811 N.	B. A. C. 3842 S. 3856 N.	B. A. C. 3919 S. 3953 N.
1855.	″	″	″	″	″	″	″	″	″	″	″	″
April 17..........	32.20	33.05	32.45	33.21	31.53	28.12	31.40	29.95	32 72	32.64	32.62	30.12
18..........	33.16	34.18	32.58	33.61	30.95	27.82	32.54	29.34	31.88	31.91	34.00	30.73
19..........	31.59	33.99	32.19	34.29	31.43	28.02	31.93	28.74	31.15	33.57	32.12	32.34
20..........	....	....	....	....	32.11	29.05	33.90	32 39	33.57	33.14	32.84	31.15
21..........	33.12	....	32.63	....	30.59	29.09	32.98	28.37	30.63	32.09	34.17	30.97
Mean of each pair..	32.51	33.71	32.46	33.70	31.32	28.42	32.55	29.75	31.99	32.67	33.15	31.06

TABLE V—Continued.

Date.	13th pair.	14th pair.	15th pair.	16th pair.	17th pair.	18th pair.	19th pair.	20th pair.	21st pair.	22d pair.	23d pair.	24th pair.
	B. A. C. 3953 N. 3992 S.	B. A. C. 3995 S. 4026 N.	B. A. C. 3995 S. 4028 N.	B. A. C. 2894 S. 2984 N.	B. A. C. 2984 N. 3000 S.	B. A. C. 2984 N. 3002 S.	B. A. C. 4059 N. 4156 S.	B. A. C. 4248 S. 4282 N.	B. A. C. 4282 N. 4318 S.	B. A. C. 4282 N. 4319 S.	B. A. C. 4345 N. 4388 S.	B. A. C. 4346 N. 4388 S.
1855.	″	″	″	″	″	″	″	″	″	″	″	″
April 17..........	26.95	32.33	33.10	....	....	....	....	....	....	....	....	....
18..........	27.18	....	....	31.47	30.65	32.45	27.26	31 55	31.65	31.47	31.35	32.54
19..........	28.51	....	....	....	26.80	30.56	27.08	32.31	33.38	33.23	....	....
20..........	27.14	....	....	....	28.41	31.06	....	31.45	32.96	33.75	....	....
21..........	27.63	....	....	....	....	....	28.08	34.36	34.20	34.10	....	....
Mean of each pair..	27.48	32.33	33.10	31.47	29.28	31.35	27.47	32.41	33.04	33.13	31.35	32.54

TABLE V—Continued.

Date.	25th pair.	26th pair.	27th pair.	28th pair.	Latitude by a mean of each night.	1st result.	2d result.	3d result.	Final result.
	B. A. C. 4408 N. 4388 S.	B. A. C. 4415 N. 4388 S.	B. A. C. 3062 S. 3085 N.	B. A. C. 4177 N. 4242 S.		Latitude by a mean of each pair.	Latitude by a mean of all the observations.	Lat. by a mean of the results for each night.	Mean of 1st, 2d, and 3d results.
1855.	″	″	″	″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
April 17..........	....	....	....	....	31 20 31.49				
18..........	33.12	34.61	....	....	31 20 32.00				
19..........	33.36	33.39	27.62	29.71	31 20 31.27				
20..........	32.90	34.18	29.28	27.54	31 20 31.43				
21..........	32.55	33.99	....	29.03	31 20 31.58				
Mean of each pair...	32.98	34.04	28.45	28.76		31 20 31.51	31 20 31.48	31 20 31.55	31 20 31.5[illegible]

TABLE VI.

Tabulation of results for the latitude of astronomical station at Agua del Perro, derived from observations made with a zenith telescope (T. & S.) on twenty-five pairs of stars: By J. H. Clark, Principal Assistant, assisted by H. Campbell.

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.	8th pair.	9th pair.	10th pair.	11th pair.
	G. C. 638 S. 675 N.	G. C. 638 S. 677 N.	G. C. 638 S. 678 N.	B. A. C. 2493 S. 2504 N.	B. A. C. 2540 S. 2592 N.	B. A. C. 2984 N. 3000 S.	B. A. C. 2605 S. 2715 N.	B. A. C. 2894 S. 2984 N.	B. A. C. 2984 N. 3002 S.	B. A. C. 3062 S. 3085 N.	B. A. C. 3170 S. 3290 N.
1855.	"	"	"	"	"	"	"	"	"	"	"
April 4	....	....	....	....	....	....	....	56.03	58.70	58.35	57.34
5	57.24	57.12	59.89	....	60.82	56.73	....	57.08	58.86	57.71	59.42
6	....	....	....	57.22	56.62	54.38	....	56.98	55.94	56.27	57.39
7	....	....	....	55.44	60 14	55.57	57.67	57.50	57.26	55.94	60.61
8	....	....	....	....	....	....	57.78	57.69	....	55.94	57.08
Mean of each pair	57.24	57.12	59.89	56 33	59.19	55.56	57.72	57.05	57.69	56.84	58.36

TABLE VI—Continued.

Date.	12th pair.	13th pair.	14th pair.	15th pair.	16th pair.	17th pair.	18th pair.	19th pair.	20th pair.	21st pair.	22d pair.
	B. A. C. 3170 S. 3297 N.	B. A. C. 3204 S. 3290 N.	B. A. C. 3204 S. 3297 N.	B. A. C. 3327 S. 3364 N.	B. A. C. 3416 N. 3500 S.	B. A. C. 3523 S. 3533 N.	B. A. C. 3548 N. 3650 S.	B. A. C. 3560 N. 3650 S.	B. A. C. 3742 S. 3811 N.	B. A. C. 3842 S. 3856 N.	B. A. C. 3919 S. 3953 N.
1855.	"	"	"	"	"	"	"	"	"	"	"
April 4	58.36	56.73	....	56.28	54.84	60.49	55.94	58.48	....	....	....
5	60.22	....	60.35	56.17	55.98	58.73	55.63	58.12	57.43	60.24	55.80
6	58.58	57.54	58.74	57.44	....	....	56.35	58.29	....	59.82	56.14
7	....	58.42	59.50	56.80	56.42	57.28	55.95	....	58.55	60.65	....
8	....	59.39	....	57.06	53.62	58.61	54.57	57.38	56.90	58.64	55.76
Mean of each pair	58.91	58.02	59.53	56.75	55.21	58.77	55.68	58.06	57.62	59.83	55.90

TABLE VI—Continued.

Date.	23d pair.	24th pair.	25th pair.		1st result.	2d result.	3d result.	Final result.
	B. A. C. 3953 N. 3992 S.	B. A. C. 3995 S. 4026 N.	B. A. C. 3995 S. 4028 N.	Latitude by a mean of each night.	Latitude by a mean of each pair.	Latitude by a mean of all the observations.	Lat. by a mean of the results for each night.	Mean of 1st, 2d, and 3d results.
1855.	"	"	"	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
April 4	....	....	....	31 20 57.41				
5	55.27	....	....	31 20 57.44				
6	....	58.77	59.85	31 20 57.43				
7	58.76	57.44	58.97	31 20 57.83				
8	....	....	....	31 20 57.08				
Mean of each pair	57.01	58.10	59.41		31 20 57.67	31 20 57.58	31 20 57.43	31 20 57.56

TABLE VII.

Tabulation of results for the latitude of astronomical station at Espia, derived from observations made with a zenith telescope (T. & S.) on twenty-three pairs of stars: By J. H. Clark, Principal Assistant, assisted by Lieut. Turnbull.

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.	8th pair.	9th pair.	10th pair.
	G. C. 638 S. 675 N.	G. C. 638 S. 677 N.	G. C. 638 S. 678 N.	B. A. C. 2540 S. 2592 N.	B. A. C. 2605 S. 2715 N.	B. A. C. 2894 S. 2984 N.	B. A. C. 2984 N. 3000 S.	B. A. C. 3002 S. 2984 N.	B. A. C. 3062 S. 3085 N.	B. A. C. 3170 S. 3290 N.
1855.	"	"	"	"	"	"	"	"	"	"
March 24	....	....	....	....	....	....	....	....	....	....
25	53.39	....	53.36	....	56.77	57.15	....	57.25	53.70	....
26	54.74	55.01	56.47	....	54.84	56.53	55.05	55.09	54.33	....
27	54.11	53.68	55.39	....	54.77	57.94	55.80	57.53	56.84	....
29	55.97	56.16	57.67	57.36	....	58.15	55.75	57.01	55.64	57.17
31	....	....	....	....	....	56.92	55.38	56.68	55.17	....
Mean of each pair	54.55	54.95	55.72	57.38	55.46	57.33	55.49	56.71	55.13	57.17

TABLE VII—Continued.

Date.	11th pair.	12th pair.	13th pair.	14th pair.	15th pair.	16th pair.	17th pair.	18th pair.	19th pair.	20th pair.
	B. A. C. 3170 S. 3297 N.	B. A. C. 3204 S. 3290 N.	B. A. C. 3204 S. 3297 N.	B. A. C. 3327 S. 3364 N.	B. A. C. 3416 N. 3500 S.	B. A. C. 3523 S. 3533 N.	B. A. C. 3610 N. 3666 S.	B. A. C. 3742 S. 3811 N.	B. A. C. 3842 S. 3856 N.	B. A. C. 3919 S. 3953 N.
1855.	"	"	"	"	"	"	"	"	"	"
March 24	....	....	....	....	....	....	58.35	56.10	....	57.59
25	....	56.32	57.84	57.08	54.91	56.32	58.92	57.68	57.94	56.33
26	....	56.21	57.02	56.19	54.51	58.89	57.42	57.15	....	57.28
27	....	57.49	....	55.81	54.87	58.21	58.21	57.76	....	....
29	58.67	56.85	58.35	57.08	56.19	55.86	59.09	57.58	59.03	56.31
31	....	....	....	....	....	....	....	....	....	....
Mean of each pair	58.67	56.71	57.53	56.64	55.12	57.32	58.39	57.25	58.48	56.87

TABLE VII—Continued.

Date.	21st pair.	22d pair.	23d pair.	Latitude by a mean of each night.	1st result.	2d result.	3d result.	Final result.
	B. A. C. 3992 S. 3953 N.	B. A. C. 3995 S. 4026 N.	B. A. C. 3995 S. 4028 N.		Latitude by a mean of each pair.	Latitude by a mean of all the observations.	Latitude by a mean of the results for each night.	Latitude by a mean of 1st, 2d, and 3d results.
1855.	"	"	"	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″
March 24	54.28	....	....	31 20 56.58				
25	53.26	56.70	58.03	31 20 56.14				
26	53.27	57.14	58.94	31 20 56.23				
27	....	....	....	31 20 56.31				
29	53.78	56.33	57.69	31 20 56.95				
31	....	....	....	31 20 56.13				
Mean of each pair	53.67	56.89	58.22		31 20 56.56	31 20 56.43	31 20 56.37	31 20 56.45

TABLE VIII.

Tabulation of results for the latitude of astronomical station at Carrizalillo, derived from observations made with a zenith telescope (T. & S.) on fourteen pairs of stars: By J. H. Clark, Principal Assistant, assisted by H. Campbell.

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.	8th pair.	9th pair.	10th pair.	11th pair.
	G. C. 389 N. 400 S.	G. C. 414 N. 400 S.	G. C. 419 N. 400 S.	G. C. 461 N. 505 S.	G. C. 570 N. 556 S.	G. C. 586 N. 589 S.	G. C. 653 N. 689 S.	G. C. 747 N. 714 S.	G. C. 747 N. 715 S.	G. C. 797 N. 792 S.	G. C. 822 N. 863 S.
1855.	"	"	"	"	"	"	"	"	"	"	"
Feb'y 24	....	....	....	....	55.09	....	....	....	56.72	52.15	54.78
25	....	55.11	55.95	....	....	....	....	....	....	54.10	52.26
26	55.64	52.00	54.29	....	....	....	....	....	....	54.84	54.10
27	54.41	53.77	55.87	....	57.73	53.50	....	....	....	54.59	53.41
March 2	....	....	....	....	54.71	55.06	57.89	....	55.41	56.59	....
3	....	....	....	56.99	54.64	55.29	56.75	....	57.71	55.39	....
5	....	....	....	56.09	53.07	54.00	54.83	....	54.83	52.50	52.52
6	....	....	....	....	54.41	....	57.26	56.82	57.16	54.64	53.86
7	....	....	....	56.70	53.62	55.95	56.80	....	58.27	54.47	54.74
8	....	....	....	57.87	54.86	54.43	....	....	....	53.87	54.12
12	....	....	....	....	54.84	55.23	56.03	55.83	55.48	56.39	....
Mean of each pair	55.02	53.62	55.37	56.91	54.77	54.78	56.59	56.32	56.51	54.50	53.72

TABLE VIII—Continued.

Date.	12th pair.	13th pair.	14th pair.	Latitude by a mean of each night.	1st result.	2d result.	3d result.	Final result.
	G. C. 869 N. 871 S.	G. C. 880 N. 939 S.	797 N., G. C. 2995 S., B. A. C.		Latitude by a mean of each pair.	Latitude by a mean of all the observations.	Lat. by a mean of the results for each night.	Latitude by a mean of 1st, 2d, and 3d results.
1855.	"	"	"	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
Feb'y 24	55.91	....	....	31 50 54.93				
25	54.71	....	....	31 50 54.42				
26	54.78	....	....	31 50 54.61				
27	56.62	....	....	31 50 54.98				
March 2	....	....	....	31 50 55.93				
3	....	....	....	31 50 56.13				
5	54.57	54.26	....	31 50 54.07				
6	56.55	....	....	31 50 55.81				
7	55.41	....	....	31 50 55.74				
8	55.38	....	....	31 50 55.09				
12	....	....	55.94	31 50 55.67				
Mean of each pair	55.74	54.26	55.94		31 50 55.29	31 50 55.19	31 50 55.21	31 50 55.23

TABLE IX.

Results for longitude of Carrizalillo, east of terminal point of parallel 31° 47′ *north latitude. Observer, J. H. Clark: Computer, H. Campbell.*

Date.		Authority for elements used.	Results for longitude from moon's 1st limb.	Date.		Authority for elements used.	Results for longitude from moon's 2d limb.
1855.			*h. m. s.*	1855.			*h. m. s.*
Feb.	23	N. A.	7 11 36. 138	March	3	N. A.	7 11 56. 145
	24	....	46. 304		4	....	51. 290
	25	....	47. 792		7	....	41. 910
	26	....	35. 111				
	27	....	43. 990				
March	1	....	41. 259				
	2	....	42. 667				

	h. m. s.		*h. m. s.*
Mean longitude from moon's 1st limb	7 11 41. 894	Mean longitude from moon's 2d limb	7 11 49. 781
		Mean longitude from moon'st 1st limb	41. 894

Mean longitude .... 7*h.* 11*m.* 45.84*s.*

Date.		Results for longitude from moon's 1st and 2d limbs.	Remarks.
		h. m. s.	
Feb.	23	7 11 36. 138	
	24	46. 304	
	25	47. 792	
	26	35. 111	
	27	43. 990	
March	1	41. 259	
	2	42. 667	
	3	56. 145	
	4	51. 290	
	7	41. 910	

Mean longitude adopted.................. 7*h.* 11*m.* 44.26*s.*

TABLE X.

Tabulation of results for the latitude of astronomical station at the Initial Point on the Rio Grande, derived from observations made with zenith telescope, (T. & S.,) on twenty-two pairs of stars: By J. H. Clark, principal assistant, assisted by H. Campbell.

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.	8th pair.	9th pair.	10th pair.
	G. C. 18 N. 170 S.	G. C. 18 N. 251 S.	G. C. 135 N. 186 S.	G. C. 170 S. 277 N.	G. C. 194 N. 244 S.	G. C. 203 N. 244 S.	G. C. 204 S. 267 N.	G. C. 230 S. 267 N.	G. C. 244. S. 252 N.	G. C. 251 S. 277 N.
1854.	″	″	″	″	″	″	″	″	″	″
Dec'r 27	....	....	51.20	....	....	49.17	....	....	48.04	....
28	....	....	52.07	....	....	50.21	....	....	49.85	....
29	....	....	49.75	....	....	51.60	....	....	50.30	....
1855.										
Jan'y 1	....	....	51.78	....	....	52.07	....	....	50.87	....
2	50.06	49.46	....	50.43	....	....	....	....	....	50.10
3	....	....	50.70	....	....	51.89	....	....	51.44	....
6	....	....	51.42	....	....	51.58	....	....	50.31	....
9	....	....	50.73	....	....	53.00	....	....	....	....
11	....	....	....	....	....	....	50.67	52.02	....	....
13	....	....	....	....	[illegible]	50.77	....	....	50.63	....
14	....	....	....	....	[illegible]	50.74	....	....	50.88	....
15	....	....	....	....	53.79	53.09	....	....	52.42	....
Mean of each pair	50.06	49.46	51.09	50.43	[illegible]	51.41	50.67	52.02	50.52	50.10

TABLE X—Continued.

Date.	11th pair.	12th pair.	13th pair.	14th pair.	15th pair.	16th pair.	17th pair.	18th pair.	19th pair.	20th pair.
	G. C. 267 N. 271 S.	G. C. 311 N. 345 S.	G. C. 370 S. 389 N.	G. C. 389 N. 400 S.	G. C. 400 S. 414 N.	G. C. 400 S. 419 N.	G. C. 430 N. 448 S.	G. C. 461 N. 505 S.	G. C. 556 S. 570 N.	G. C. 586 N. 589 S.
1854.	″	″	″	″	″	″	″	″	″	″
Dec'r 27	50.73	51.56	52.28	....	51.25	53.40	51.10	52.54	52.04	51.89
28	51.69	51.97	50.21	....	51.92	....	53.65	....	50.55	51.77
29	....	50.84	49.10	....	50.04	53.05	52.21	....	....	....
1855.										
Jan'y 1	50.91	....	[illegible]	....	52.39	....	53.16	....	....	....
2	....	51.82	51.17	....	51.25	....	51.76	....	51.88	50.68
3	....	....	50.30	....	51.33	....	50.77	....	52.11	[illegible]
6	51.58	52.23	51.84	....	48.86	....	50.80	....	51.44	50.19
9	50.61	52.30	51.40	....	50.29	....	....	....	....	....
11	50.67	52.51	....	53.13	52.16	53.92	[illegible]	....	....	....
13	50.42	....	51.07	....	51.23	[illegible]	50.56	....	....	....
14	51.32	49.88	....	....	50.64	[illegible]	50.67	....	....	....
15	52.11	53.88	50.19	....	51.25	53.16	49.95	....	....	....
Mean of each pair	51.11	51.85	50.99	53.13	51.05	[illegible]	[illegible]	52.54	51.60	51.08

TABLE X—Continued.

Date.	21st pair. G. C. 653 N. 661 S.	22d pair. G. C. 652 N. 661 S.	Latitude by a mean of each night.	1st result. Latitude by a mean of each pair.	2d result. Latitude by a mean of all the observations.	3d result. Latitude by a mean of the results for each night.	Final result. Mean of 1st, 2d, and 3d results.
1854.	″	″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
Dec'r 27	50.71	....	31 46 51.22				
28	....	....	31 46 51.39				
29	....	....	31 46 50.86				
1855.							
Jan'y 1	....	....	31 46 51.03				
2	....	50.01	31 46 50.78				
3	49.50	....	31 46 50.99				
6	....	51.85	31 46 51.12				
9	....	....	31 46 51.39				
11	....	....	31 46 52.79				
13	....	....	31 46 51.06				
14	....	....	31 46 51.13				
15	....	....	31 46 52.17				
Mean of each pair...	50.10	50.93		31 46 51.23	31 46 51.30	31 46 51.35	31 46 50.29

9.—*Azimuths for laying off the prime vertical of stations from 1 to 8, inclusive.*

Measurements for establishing the prime vertical at the initial point of parallel 31° 47′.

JANUARY 7, 1855.

Reading of azimuth circle instrument in true meridian, previously determined by transit observations.				Reading of azimuth circle instrument in prime vertical.			
Ver. A.	B.	C.	D.	A.	B.	C.	D.
° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
90 00 00	180 00 05	270 00 07	....	180 00 00	270 00 15	359 59 55	89 59 40
89 59 55	180 00 00	269 59 55	359 59 45	180 00 05	270 00 15	360 00 10	90 00 00
89 59 55	180 00 00	270 00 05	360 00 05	....	....	....	....
89 59 56.6	180 00 01.6	270 00 02.3	359 59 55	180 00 02.5	270 00 15	360 00 02.5	89 59 50

Observations for the determination of the true meridian at San Luis Springs.

APRIL 20, 1855.

Time of observation by chronometer 2419, sidereal.	Reading of azimuth circle, telescope directed on star. Ver. 1.	2.	3.	4.	Reading of azimuth circle when plane of instrument stands in true meridian. Ver. 1.	2.	3.	4.	Computed azimuth of Polaris west of north at each observation.	Remarks.
h. m. s.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	
11 42 18	181 29 15	271 29 10	1 29 15	91 29 15	179 58 23.9	269 58 19.4	359 58 19.4	89 58 20.9	1 30 54.1	Chronometer 2419 is fast 2*h.* 42*m.* 0.57*s.*
11 54 14.7	181 26 30	271 26 25	1 26 15	91 26 25	179 58 14.7	269 58 09.7	359 58 00	89 58 09.9	1 28 15.3	The reading of azimuth circle when telescope was directed on signal = zero.
12 02 00.9	181 24 10	271 24 10	1 24 00	91 24 05	179 58 28.9	269 58 28.9	359 58 19	89 58 24	1 25 41.10	Error of signal from true meridian west of north = 1′ 41″.8.
					179 58 22.5	269 58 19.3	359 58 12.8	89 58 18.2		

	′ ″
Ver. No 1	1 37.5
2	1 40.7
3	1 47.2
4	1 41.8
Mean	1 41.8

9.—*Azimuths for laying off the prime vertical, &c.*—Continued.

Observations for the determination of the true meridian at San Luis Springs.

APRIL 22, 1855.

Time by chronometer 2419, sidereal.	Reading of azimuth circle, telescope directed on star. Ver. 1.	2.	3	4.	Reading of azimuth circle, telescope directed on signal. Ver. 1.	2.	3.	4.	Reading of azimuth circle when plane of inst. stands in true meridian. Ver. 1.	2.	3.	4.	Computed azimuth of Polaris west of N. at each observation.	Results
h. m. s.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″
11 51 26.6	91 27 20	181 27 10	271 27 20	1 27 30	90 00 15	180 00 00	270 00 10	0 00 25	89 58 24.8	179 58 14.8	269 58 24.8	0 58 34.8	1 28 55.26	1 47.70
12 11 55 7	91 22 30	181 22 10	271 22 25	1 22 35	90 00 30	180 00 05	270 00 35	0 00 55	89 58 35 1	179 58 16 1	269 58 31.1	0 58 41.1	1 23 53.9	1 58.67
12 31 05.7	91 17 40	181 17 25	271 17 35	1 17 50	....	....	....	....	89 59 05.1	179 58 50.1	269 59 00.1	0 59 15	1 18 34 9	57.42
12 41 20.6	91 14 40	181 14 25	271 14 40	1 14 50	90 01 00	180 00 45	270 01 05	0 01 20	89 59 10	179 58 55	269 59 10	0 59 20	1 15 30	1 57 50
					90 00 35	180 00 16.6	270 00 36.6	0 00 53.3	89 58 49.0	179 58 34.0	269 58 46.5	0 58 57.72	....	1 40.32

	′ ″
Error of signal from true meridian West of North....................................	1 40.32
Result April 20..	1 41.80
Error of signal by a mean of two nights' observations..........................	1 41.06

Observations for the determination of the true meridian at San Bernardino.

APRIL 28, 1855.

Time of observation by chronometer 2419, sidereal.	Reading of azimuth circle, telescope directed on star. Ver. 1	2	3	4	Reading of azimuth circle, telescope directed on signal. Ver. 1	2	3	4	Mean difference of readings at each observation.	Azimuth of Polaris at each observation deduced from east elongation.	Error of signal from true meridian by each observation.
h. m. s.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″
21 51 01.4	89 59 50	179 59 35	269 59 40	0 00 45	91 11 40	181 11 35	271 11 45	1 12 05	1 11 48 75	1 42 53.46	30 63.71
22 01 07.9	89 59 35	179 59 40	269 59 45	0 00 15	91 11 30	181 11 27.5	271 11 40	1 12 00	1 11 50.6	1 42 40.76	30 50.16
22 08 06.9	89 59 50	179 59 45	270 00 02	0 00 20	91 11 30	181 11 27.5	271 11 40	1 12 00	1 11 40	1 42 25.68	30 45.68
22 13 51.6	90 00 05	179 59 40	270 00 07.5	0 00 25	91 11 30	181 11 27.5	271 11 40	1 12 00	1 11 35	1 42 08.96	30 33.96

Error of signal from true meridian E. of N. = 30′ 48″.37.

APRIL 29, 1855.

Time of observation by chronometer 2419, sidereal.	Reading of azimuth circle, telescope directed on star. Ver. 1	2	3	4	Reading of azimuth circle, telescope directed on signal. Ver. 1	2	3	4	Mean difference of readings at each observation.	Azimuth of Polaris at each observation deduced from east elongation.	Error of signal from true meridian by each observation.
h. m. s.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″
21 54 47.1	359 59 15	89 59 10	179 59 20	269 59 35	1 11 45	91 11 32.5	181 11 42	271 11 50	1 12 22.37	1 42 49.57	30 27.20
22 01 37	359 59 20	89 59 10	179 59 15	269 59 35	1 11 45	91 11 33.5	181 11 42	271 11 50	1 12 22 34	1 42 40.00	30 17.66
22 20 02.9	0 00 22	90 00 02.5	180 00 23.5	270 00 32 5	1 11 35	91 1 15	181 11 40	271 11 45	1 11 13.87	1 41 46.83	30 32.96

Error of signal from true meridian E. of N. = 30′ 29″.94.

9.—*Azimuths for laying off the prime vertical, &c.*—Continued.

Observations for the determination of the true meridian at San Bernardino—Continued.

APRIL 30, 1855.

Time of observation by chronometer 2419, sidereal.	Reading of azimuth circle, telescope directed on star.				Reading of azimuth circle, telescope directed on signal.				Mean difference of readings at each observation.	Azimuth of Polaris at each observation deduced from east elongation.	Error of signal from true meridian by each observation.
	Ver. 1	2	3	4	Ver. 1	2	3	4			
h. m. s.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″
21 35 38.5	358 47 55	88 48 00	178 47 45	268 47 40	359 59 45	89 59 50	179 59 40	269 59 20	1 11 48.75	1 42 47.33	30 58.58
21 49 08.6	358 47 45	88 47 40	178 47 45	268 47 30	359 59 45	89 59 50	179 59 35	269 59 25	1 11 58.75	1 42 53.35	30 54.60
22 09 35.8	358 47 45	88 47 55	178 47 40	268 47 35	359 59 42	89 59 40	179 59 25	269 59 20	1 11 48.12	1 42 22.04	30 33.92

	′ ″
Error of signal from true meridian	30 49.03
April 29, signal from true meridian	30 25.94
April 28, signal from true meridian	30 48.37
Mean error of signal from true meridian E. of N.	30 41.11

Observations for the determination of the true meridian at camp near the head of the Santa Cruz river.

MAY 10, 1855.

Time of observation by chronometer 2419, sidereal.	Reading of azimuth circle, telescope directed on star.				Reading of azimuth circle, telescope directed on signal.				Mean difference of readings at each observation.	Azimuth of Polaris at each observation deduced from east elongation.	Error of signal from true meridian by each observation.
	Ver. 1	2	3	4	Ver. 1	2	3	4			
h. m. s.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
21 44 51.8	170 03 15	260 03 20	350 03 22.5	80 03 30	179 59 45	269 59 45	359 59 50	89 59 55	9 56 26.87	1 42 52.09	8 13 34.78
21 55 32.9	170 03 15	260 03 10	350 03 15	80 03 20	179 59 45	269 59 30	359 59 50	89 59 50	9 56 28.70	1 42 54.67	8 13 34.03
22 10 37.8	170 03 15	260 03 10	350 03 17	80 03 25	179 59 45	269 59 35	359 59 50	89 59 55	9 56 29.50	1 42 35.48	8 13 54.50

Error of signal on true meridian West of North, 8° 13′ 41″.10.

Observations at the intersection of the parallel 31° 20′ and the 111th° of longitude west from Greenwich for the determination of the true meridian.

JUNE 14, 1855.

Time of observation by chronometer 2419, siderial.	Reading of azimuth circle, telescope directed on star.			Reading of azimuth circle, telescope directed on signal.			Mean difference of readings at each observation.	Azimuth of Polaris at each observation deduced from east elongation.	Error of signal from true meridian by each observation.	Remarks.
	Ver. 1	2	3	Ver. 1	2	3				
h. m. s.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	
21 43 12.5	120 18 45	0 18 45	240 19 10	117 59 00	257 59 15	237 58 45	2 19 50	1 42 52.4	36 57 46	Chronometer 2419 fast 2*h*. 54*m*. 20*s*.
21 51 34.5	120 19 30	0 19 30	240 19 15	117 59 15	257 59 15	237 59 30	2 20 05	1 43 01.7	37 03 26	

Azimuth of signal by a mean of two observations on Polaris East of North, 37′ 00″.36.

9.—*Azimuths for laying off the prime vertical, &c.*—Continued.

Observations at the intersection of the parallel 31° 20′ and the 111th° of longitude west from Greenwich, &c.—Continued.

JUNE 15, 1855.

Time of observation by chronometer 2419, sidereal.	Reading of azimuth circle, telescope directed on star.		Reading of azimuth circle, telescope directed on signal.		Mean difference of readings at each observation.	Azimuth of Polaris at each observation deduced from east elongation.	Error of signal from true meridian by each observation.	Remarks.
	Ver. 1	2	Ver. 1	2				
h. m. s.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	
21 22 10.5	312 10 50	132 10 55	309 52 15	129 52 20	2 18 35	1 41 52.7	36 42.30	Chronometer 2419 fast 2h. 54m. 25s.
21 27 23.5	312 11 15	132 11 05	309 52 15	120 52 20	2 18 52	1 42 12.35	36 39.65	Azimuth of signal by a mean of ten observation on Polaris East of North, 36′ 55″.59.
21 44 22.5	312 11 45	132 12 10	309 52 10	129 52 30	2 19 37.5	1 42 54.27	36 43.24	
21 50 58	312 12 10	132 12 25	309 52 10	129 52 30	2 19 57.5	1 43 01.29	36 55.21	
21 55 48	312 12 !5	132 12 20	309 52 10	129 52 30	2 19 57.5	1 43 03.24	36 54 26	
21 58 47	312 12 40	132 12 20	309 52 10	129 52 25	2 20 15	1 43 03.07	37 11.93	
22 06 46	312 12 00	132 12 20	309 52 10	129 52 25	2 19 52.5	1 42 57.41	36 54.04	
22 10 38	312 11 55	132 12 10	309 52 10	129 52 25	2 19 45	1 42 52.05	36 52.95	
22 19 06.5	312 12 00	132 12 15	309 52 10	129 52 25	2 19 50	1 42 34.03	37 15.97	
22 25 07	312 11 30	132 11 45	309 52 00	129 52.30	2 19 22.5	1 42 16.13	37 06.37	

	′ ″
Result June 14th..	37 06.36
Result June 15th..	36 55.59
Azimuth of signal by a mean of two nights' observations on Polaris..............	36 57.97

10.—*Elements for marking parallels of latitude* 31° 20′ *and* 31° 47′.

PARALLEL 31° 20′.

Distances from point of beginning (on tangent.)		Length of offset from tangent (= difference of latitude.)		Latitude of points on tangent.	Azimuth of tangent at several points bearing North East.	Longitude of points *five miles* apart on the parallel of 31° 20′.
Miles.	Feet.	In arc.	In feet.			
		″		° ′ ″	° ′ ″	° ′ ″
0	0	0.000	0.000	31 20 00.00	90 00 00.0	0 00 00.00
1	0	0.004	0.4	00.00	89 59 43.3	1 00.88
5	0	0.100	10.1	19 59.90	57 21.7	5 04.413
10	0	0.401	40.5	59.60	54 43.4	10 08.826
15	0	0.902	91.1	59.10	52 05.0	15 13.24
20	0.8	1.604	162.0	58.40	49 26.8	20 16.75
25	1.2	2.506	253.2	57.50	46 48.5	25 22.06
30	1.7	3.609	364.6	56.39	44 10.2	30 26.48
35	2.6	4.913	496.4	55.09	41 32.0	35 30.89
40	4.3	6.417	648.4	53.58	38 53.7	40 35.33
45	6.0	8.121	820.5	51.88	36 15.9	45 39.70
50	7.7	10.026	1013.0	49.97	33 37.2	50 44.13
55	10.3	12.131	1225.7	47.87	30 58.9	55 48.54
60	13.8	14.437	1458.7	45.56	28 21.6	1 00 52.96
64 +972 ft.	16.6	16.522	1669.3	43.48	26 08.2	1 06 07.69
100	62.4	40.115	4056.2	19.89	07 15.0	1 41 28.26

10.—*Elements for marking parallels, &c.*—Continued.

PARALLEL 31° 47′.

Distance, in miles, from the point of beginning.	Length of offset (= difference of latitude.) In arc.	Length of offset (= difference of latitude.) In feet.	Latitude at the end of any distance on the tangent.	Azimuth of the tangent at any distance bearing North East.	Longitude of the point of the parallel determined by each offset.
	″		° ′ ″	° ′ ″	′ ″
1	0.004	0.4	31 47 00.00	89 59 43.0	1 01.17
5	0.102	10.3	46 59.90	57 18.9	5 05.88
10	0.408	41.2	59.59	54 37.8	10 11.75
15	0.918	92.7	59.08	51 56.7	15 17.63
20	1.632	164.9	58.37	49 15.5	20 23.50
25	2.550	257.6	57.45	46 34.5	25 29.37
30	3.673	371.1	56.33	43 53.0	30 35.24
35	5.000	505.2	55.00	41 12.2	35 41.11
40	6.530	659.8	53.47	38 31.2	40 46.97
45	8.265	835.0	51.74	35 50.0	45 52.83
50	10.203	1030.9	49.80	33 09.0	50 58.68
55	12.346	1247.4	47.65	30 08.0	56 04.53
60	14.692	1484.4	45.31	27 47.0	61 10.37

Log. N in feet.................. = 7.3210287
Log. (1 + e² cos. ²L) .... = 0.0021098
Log. 2 sin 1″.................. = 4.9866049
Log. sin 1″.................... = 4.6855749

1° of parallel................ = 104,069.2 yds.
10′ of parallel................ = 17,344.87 "
1′ of parallel................ = 1,734.487 "
1″ of parallel................ = 28.908 "
1″ of parallel................ = 86.724 feet.

$$L - l = D^2 \frac{\text{tang. } L\,(1 + e^2 \cos L)}{N^2\, 2 \sin 1''}$$

$$Z = 90^\circ - D \text{ tang. } l \frac{1}{N \sin 1''}$$

$$\text{Diff. long.} = D \frac{1}{N \sin 1''} \frac{1}{\cos l}$$

D = distance in feet, measured on tangent.
L = lat. of points of beginging of ditto.
l = lat. of any point of tangent.
Z = azimuth of tangent line at any point.

Log. $(L - l)$ = log. (D^2) + 0.1579269
Log. 2 sin 1″ = 4.9866049
Log. sin 1″ = 4.6855749

MEMORANDA.

		°	′	″
One hundred miles of parallel of 31° 47′	=	1	41	57.55
Longitude of initial point of parallel on Rio Bravo, (by survey from Frontera.) ..		106	31	26.50
Longitude of terminal point of parallel 31° 47′........		108	13	24.05
Longitude of terminal point of parallel 31° 20′, (by treaty)........	=	111	00	00.00

		°	′	″
Length of parallel 31° 20′—in arc........	=	2	46	35.95
Do............do....... in yards		288964.03		
Do............do....... in feet........		866892.10		
Do............do....... in miles and feet	=	164 miles + 972 feet.		
One degree of parallel of latitue 31° 47′........	=	103,570.85 yards.		
One minute of........do........do........		1,726.18 "		
One second of........do........do........		28.77 "		
Or in feet	=	86.310		
One degree of parallel of latitude 31° 20′........	=	104,069.2 yards.		
One minute of........do........do........		1,734.487 "		
One second of........do........do........		28.908 "		
Or in feet........	=	86.724		
From parallel 31° 20′ to 31° 47′ = 27′........	=	31 miles + 5.37 feet.		
One degree of meridian (middie latitude being 31° 33½)........	=	121,248.43 yards.		
One minute of ....do............do............do........		2,020.807 "		
One second of ....do............do............do........		33.680 "		
Or in feet........	=	101.04		

ASTRONOMICAL POSITIONS

ALONG

THE RIO BRAVO DEL NORTE.

D.—BOUNDARY LINE FORMED BY THE RIO BRAVO DEL NORTE.

OFFICE OF SURVEY OF THE UNITED STATES AND MEXICAN BOUNDARY,
Washington, D. C., May 22, 1856.

SIR: In my communication of February 9, 1856, I presented to you the final results for the longitudes of the astronomical station, established under your direction in the year 1853, near the mouth of Rio Bravo del Norte, the same having been computed with corresponding observations made at Greenwich, Philadelphia High School, and Radcliffe observatories.

I have now to present, in a tabular form, the individual results of all the observations made by you and under your orders for the longitudes and latitudes of the primary astronomical positions on and near the Rio Bravo del Norte, established in connexion with the survey of the United States and Mexican boundary.

I.—LONGITUDES.

The positions thus determined are eight in number, being enumerated as follows in the order of place from the west:

a. Frontera.
*a*¹. San Elceario.
b. El Paso del Norte.
c. Mouth of Cañon.
d. Presidio del Norte.
e. Fort Duncan, Texas.
f. Ringgold Barracks.
g. Mouth of Rio Bravo del Norte.

All the observations made at these places, together with the computations, as well as the elements and data used therein, are *herewith* presented in a tabular form, comprising the corresponding observations made at Greenwich, Cambridge, Philadelphia High School, and Radcliffe observatories.*

Attached to this is also a recapitulation of the results, from which are deduced the final longitude adopted for each station, the papers being marked *a*, *a*¹, *b*, *c*, *d*, *e*, *f*, *g*, to each of which I will briefly call your attention.

a. Frontera.—The observations at this place extend through four lunations, commencing December 29, 1851, and ending April 6, 1852; making, as combined in table (I,) the longitude $=7^h\ 6^m\ 13^s.02$ west of Greenwich.

* These computations are to be deposited in the Department of the Interior, in manuscript form.

a^1. *San Elceario.*—Moon culminations were observed at this place simultaneous with those observed at Frontera. These observations extend through a period of five lunations, commencing January 29, and ending June 3, 1852; making, as combined in table (II,) the longitude of San Elceario=$7^h\ 5^m\ 4^s.43$ west of the meridian of Greenwich.

This result, however, as well as that above given for Frontera, has been corrected by combining with them the difference of longitude of these places, as determined by flashes of gunpowder simultaneously observed at Frontera, El Paso del Norte, and San Elceario, on the nights of February 14, 18, 19, and March 14, 1852, (see table III,) by which it appears that San Elceario is east of Frontera=$1^m\ 7^s.30$, whilst that deduced from moon culminations, $1^m\ 8^s.59$; difference,=$1^s.29$.

The longitudes of Frontera and San Elceario, as determined from moon culminations, being corrected by half the difference $\frac{1^s.29}{2}$, gives for the final adopted longitude of Frontera $7^h\ 6^m\ 12^s.37$; San Elceario, $7^h\ 5^m\ 5^s.07$.

b. El Paso del Norte being, as determined by flashes, $15^s.94$ east of Frontera, it is therefore in longitude=$7^h\ 5^m\ 56^s.43$ west of the meridian of Greenwich.

c. The astronomical station "near the *mouth of the Cañon,*" on the left bank of Rio Bravo del Norte, is in longitude=$7^h\ 2^m\ 29^s.06$; having been determined, in the absence of moon culminations, by thirteen flashes of gunpowder, simultaneously observed at that station and San Elceario, on the night of June 21, 1852, to be $2^m\ 36^s.0$ east of San Elceario.—(See table IV.)

d. The astronomical station near *Presidio del Norte*, on the left bank of Rio Bravo del Norte, was determined by a series of moon culminations, observed during a period of two lunations, commencing July 26, 1852, and ending August 29, 1852, determining its position to be $6^h\ 57^m\ 39^s.02$ west of the meridian of Greenwich.—(See table V.)

e. The astronomical station near *Fort Duncan*, Texas, was determined to be in longitude $6^h\ 42^m\ 1^s.78$ west of the meridian of Greenwich, from observed moon culminations, commencing October 19, and ending October 27, 1852, combined as per table herewith marked VI.

f. Ringgold Barracks is in longitude $6^h\ 35^m\ 6^s.19$, as determined by moon culminations observed on ten nights during the months of June and July, 1853, the several results being combined as per table herewith, marked VII.

g. The longitude of the astronomical station near the *mouth of the Rio Bravo del Norte* has already been discussed by me, as presented to you in report of February 19, 1856, (herewith appended, marked *g,*) to which I refer you for the conclusion of the subject of the longitudes of the primary points on the Rio Bravo; it explains in detail the manner in which all the observations and computations have been tabulated, for which reason I have not herein before made reference thereto.

II. Latitudes.

The two volumes herewith* (marked *Latitudes,*) contain, in a tabulated form, all the individual observations made by yourself with the zenith instrument, for determining the latitudes of all the primary astronomical stations on and near the Rio Bravo del Norte, from Frontera down to its mouth, with the exception of San Elceario and Fort Duncan; of these two, the former was determined in 1851, by Lieutenant Whipple, topographical engineers, by transits of stars over the prime vertical, and the latter in 1852, by Lieutenant Michler, topographical engineers, by circum-meridian altitudes of N. and S. stars observed with a sextant.

* To be deposited in the Department of the Interior.

The tables appended present a recapitulation of all the results for the latitudes of the primary stations, giving results which have been adopted, as follows, viz:

a. Frontera, by a mean of 106 observations made by W. H. Emory, on twenty-four pairs of stars observed near the zenith, is determined by combining the results, as in table herewith, marked VIII, to be in latitude = 31° 48′ 44″.53.

The table marked IX, indicates the corrections derived from actual observations of the stars at the Washington Observatory, which corrections have been applied as indicated in table IX*a*.

*b. San Elceario** was determined by Lieutenant Whipple in 1851, by twenty prime vertical observations on eight stars, to be in latitude 31° 35′ 12″.62, the individual results being combined as shown in table X.

c. Astronomical station near the *mouth of Cañon* is in latitude 31° 2′ 26″.15, as determined by Major Emory in 1852, from fifty observations on twenty-one pairs of stars near the zenith; the individual results being combined as shown in table marked XI. Table XI*a*, shows the corrections which have been applied as indicated in table XI, in order to introduce the stars' elements as given in the "Twelve-Year Catalogue."

d. Astronomical station near *Presidio del Norte* is in latitude 29° 34′ 7″.13, as determined by Major W. H. Emory in 1852, from 121 observations on twenty-six pairs of stars near the zenith, combined as shown in table marked XII. Table XII*a*, shows the corrections which have been applied as indicated in table XII, in order to introduce the stars' positions as given in the "Twelve-Year Catalogue."

e. Fort Duncan (Eagle Pass) is in latitude 28° 42′ 43″.67, as determined by Lieutenant N. Michler, topographical engineers, in 1852, from eighty-seven altitudes of north and south stars, observed with a sextant, combined as in table marked XIII.

f. Ringgold Barracks (observatory) is in latitude 26° 22′ 27″.79, as determined by Major Emory in 1853, from 107 observations on thirty-two pairs of stars near the zenith, combined as shown in table marked XIV. Table XIV*a*, shows the corrections which have been applied as indicated in table XIV, in order to give to the stars their positions furnished in the "Twelve-Year Catalogue."

g. The astronomical station near the *mouth of Rio Bravo del Norte* is in latitude 25° 57′ 21″.83, as determined by Major W. H. Emory in 1853, from 129 observations on twenty pairs of stars near the zenith, combined as shown in table marked XV.

The papers herewith have been arranged in this manner with a view to facilitate you in preparing them for such further use as you may deem best.

Very respectfully, your obedient servant,

GEO. THOM,

Captain Topographical Engineers.

Major WM. H. EMORY, *United States Commissioner.*

* This place was subsequently determined by myself, not knowing that Lieutenant Whipple had observed there; but finding he had done so, I gave his observations priority.—W. H. E.

TABLE I.

Tabulation of results for longitude of astronomical station at Frontera observatory, derived from observations made with the bronzed transit and sidereal chronometer No. 2440, (by Parkinson & Frodsham:) By Major Wm. H. Emory, Chief Astronomer and Surveyor United States and Mexican boundary survey.*

Date.	Moon's first limb.	Date.	Moon's sec'd limb.
1851.	*h. m. s.*	1852.	*h. m. s.*
Dec. 29	7 06 05.1	Jan. 7	7 06 08.7
30	08.2	8	22.0
31	13.1	9	15.4
1582.		10	06.4
Jan. 1	09.0		21.2
2	13.2		
	h. m. s.		*h. m. s.*
Mean..........	=7 06 08.66	Mean—2d limb ...	=7 06 14.74
		Mean—1st limb...	= 08.66
Mean longitude from first lunation			*h. m. s.* =7 06 11.70

Date.	Moon's first limb.	Date.	Moon's sec'd limb.
1852.	*h. m. s.*	1852.	*h. m. s.*
Feb. 28	7 06 06.0	Mar. 4	7 06 20.0
29	08.1	5	13.8
Mar. 1	17.8	6	09.6
2	14.1	8	14.8
3	13.3		
4	19.7		
5	17.4		
	h. m. s.		*h. m. s.*
Mean..............	=7 06 13.77	Mean—2d limb ...	=7 06 14.55
		Mean—1st limb...	= 13.77
Mean longitude from third lunation....................			*h. m. s.* =7 06 14.16

Date.	Moon's first limb.	Date.	Moon's sec'd limb.
1852.	*h. m. s.*	1852.	*h. m. s.*
Jan. 29	7 06 16.6	Feb. 4	7 06 10.2
30	11.2	5	06.3
Feb. 1	17.7	7	14.2
2	19.6	9	13.6
4	09.1	10	07.7
		11	17.1
	h. m. s.		*h. m. s.*
Mean..........	=7 06 14.96	Mean—2d limb ...	=7 06 11.52
		Mean—1st limb...	= 14.96
Mean longitude from second lunation................			*h. m. s.* =7 06 13.24

Date.	Moon's first limb.	Date.	Moon's sec'd limb.
1852.	*h. m. s.*	1852.	*h. m. s.*
Mar. 31	7 06 08.6	April 4	7 06 13.9
April 1	05.6	5	13.0
2	16.1	6	19.8
	h. m. s.		*h. m. s.*
Mean..............	=7 06 10.1	Mean—2d limb ...	=7 66 15.87
		Mean—1st limb...	= 10.10
Mean longitude from fourth lunation....................			*h. m. s.* =7 06 12.98

Lunation.	Longitude deduced.
	h. m. s.
First	7 06 11.70
Second	7 06 13.24
Third	7 06 14.16
Fourth..	7 06 12.98

	h. m. s.
* Longitude of Frontera..............................	=7 06 13.02

* Reduced from Greenwich observations for 1851–'52.

TABLE II.

Tabulation of results for longitude of astronomical station at San Elceario, Texas, derived from observations made with transit (by Troughton & Simms) and mean solar chronometer No. 76, (by Charles Young:) By Lieut. William F. Smith, topographical engineers, and by J. Lawson, under the direction of Major W. H. Emory, chief astronomer and surveyor of the United States and Mexican boundary survey.

Date.	Authority for elements used.	Moon's 1st limb.	Resulting longitude from observations on moon's 1st l'b.
1852.		h. m. s.	h. m. s.
Jan. 29	Greenwich Right Ascensions	7 05 06.07	
	Cambridge observations.....	7 05 05.77	7 05 05.96
	Cambridge Right Ascensions.	7 05 06.04	
30	Greenwich Right Ascensions	7 04 59.80	7 04 59.45
	Greenwich observations.....	7 04 59.09	
31	Greenwich Right Ascensions.	....	7 05 01.30
Feb. 1	Greenwich Right Ascensions.	7 04 58.70	7 04 59.20
	Greenwich observations.....	7 04 59.70	
2	Greenwich Right Ascensions.	....	7 05 03.50
4	Greenwich Right Ascensions.	....	7 05 01.80

Mean longitude from moon's 1st limb = 7*h.* 05*m.* 01*s.*87

Date.	Authority for elements used.	Moon's 2d limb.	Resulting longitude from observations on moon's 2d l'b.
		h. m. s.	h. m. s.
Feb. 8	Greenwich Right Ascensions.	....	7 05 04.4
9	Greenwich Right Ascensions.	....	7 05 02.1
11	Greenwich Right Ascensions.	....	7 05 01.9
12	Greenwich Right Ascensions.	....	7 05 06.9

Mean longitude from moon's 2d limb = 7*h.* 05*m.* 03*s.*83
Mean longitude from moon's 1st limb = 7*h.* 05*m.* 01*s.*87

Mean longitude from 1st lunation = 7*h.* 05*m.* 02*s.*85.

Date.	Authority for elements used.	Moon's 1st limb.	Resulting longitude from observations on moon's 1st l'b.
1852.		h. m. s.	h. m. s.
Feb. 28	Greenwich Right Ascensions.	....	7 05 02.7
29	Greenwich Right Ascensions.	7 05 03.6	7 05 03.0
	Greenwich observations. ...	7 05 02.4	
March 1	Greenwich Right Ascensions.	7 05 06.6	7 05 05.4
	Washingt'n Right Ascensions	7 05 04.2	
2	Greenwich Right Ascensions.	7 05 08.4	
	Greenwich observations.....	7 05 08.9	
	Washingt'n Right Ascensions	7 05 07.1	7 05 07.22
	Cambridge Right Ascensions.	7 05 03.3	
	Cambridge observations.....	7 05 08.4	
4	Greenwich Right Ascensions.	....	7 05 04.3
5	Greenwich Right Ascensions.	7 05 05.6	7 05 05.4
	Greenwich observations.....	7 05 05.2	

Mean longitude from moon's 1st limb = 7*h.* 05*m.* 04*s.*67

Date.	Authority for elements used.	Moon's 2d limb.	Resulting longitude from observations on moon's 2d l'b.
1852.		h. m. s.	h. m. s.
March 5	Greenwich Right Ascensions.	7 05 08.8	7 05 07.65
	Greenwich observations.....	7 05 08.5	
7	Greenwich Right Ascensions.	....	7 05 09.8

Mean longitude from moon's 2d limb = 7*h.* 05*m.* 08*s.*73
Mean longitude from moon's 1st limb = 7*h.* 05*m.* 04*s.*67

Mean longitude from 2d lunation = 7*h.* 05*m.* 06*s.*70.

TABLE II—Continued.

Date.	Authority for elements used.	Moon's 1st limb.	Resulting longitude from observations on moon's 1st l'b.
1852.		h. m. s.	h. m. s.
March 29	Greenwich Right Ascensions.	....	7 05 02.1
30	Greenwich Right Ascensions.	....	7 05 11.5
April 1	Greenwich Right Ascensions.	7 05 05.8	7 05 07.63
	Greenwich observations.....	7 05 07.6	
	Cambridge Right Ascensions.	7 05 10.4	
	Cambridge observations.....	7 05 06.7	
2	Greenwich Right Ascensions.	7 05 05.6	7 05 07.75
	Greenwich observations.....	7 05 09.9	

Mean longitude from moon's 1st limb = 7*h*. 05*m*. 07*s*.24.

Date.	Authority for elements used.	Moon's 2d limb.	Resulting longitude from observations on moon's 2d l'b.
1852.		h. m. s.	h. m. s.
April 4	Greenwich Right Ascensions.	....	7 05 07.9
5	Greenwich Right Ascensions.	....	7 05 01.5
6	Greenwich Right Ascensions.	....	7 05 01.5

Mean longitude from moon's 2d limb = 7*h*. 05*m*. 03*s*.80.
Mean longitude from moon's 1st limb = 7*h*. 05*m*. 07*s*.24.

Mean longitude from third lunation = 7*h*. 05*m*. 05*s*.27.

Date.	Authority for elements used.	Moon's 1st limb.	Resulting longitude from observations on moon's 1st l'b.
1852.		h. m. s.	h. m. s.
April 29	Greenwich Right Ascensions.	7 05 00.5	7 05 02.73
	Cambridge Right Ascensions.	7 05 05.7	
	Cambridge observations.....	7 05 02.0	

Date.	Authority for elements used.	Moon's 1st limb.	Resulting longitude from observations on moon's 1st l'b.
1852.		h. m. s.	h. m. s.
April 30	Cambridge Right Ascensions.	7 05 02.8	7 05 03.05
	Cambridge observations. ...	7 05 03.3	

Mean longitude from moon's 1st limb = 7*h*. 05*m*. 02*s*.89.

Date.	Authority for elements used.	Moon's 1st limb.	Resulting longitude from observations on moon's 1st l'b.
1852.		h. m. s.	h. m. s.
May 28	Greenwich Right Ascensions.	7 05 03.3	7 05 02.63
	Cambridge Right Ascensions.	7 05 02.9	
	Cambridge observations.....	7 05 01.7	
29	Greenwich Right Ascensions.	....	7 05 10.20
31	Greenwich Right Ascensions.	7 05 00.6	7 05 01.10
	Greenwich observations.....	7 05 01.6	
June 1	Greenwich Right Ascensions.	....	7 05 02.30

Mean long. from moon's 1st limb.................. = 7*h*. 05*m*. 04*s*.06
Mean long. from moon's 1st limb, by preceding lunation = 7*h*. 05*m*. 02*s*.89

Date.	Authority for elements used.	Moons 2d limb.	Resulting longitude from observations on moon's 2d l'b.
1852.		h. m. s.	h. m. s.
June 3	Greenwich Right Ascensions.	....	7 05 01.4

Mean long. from moon's 2d limb.................... = 7*h*. 05*m*. 01*s*.40
Mean of last two lunations from moon's first limb.... = 7*h*. 05*m*. 03*s*.48

Mean longitude from fourth and fifth lunations = 7*h*. 05*m*. 02*s*.44.

		h. m. s.
Longitude of San Elceario from first lunation..............................	=	7 05 02.85
Do..........do.......from second lunation..............................	=	7 05 06.70
Do..........do.......from third lunation..............................	=	7 05 05.27
Do.... .....do.......from fourth and fifth lunations..............................	=	7 05 02.44

Longitude of San Elceario = 7*h*. 05*m*. 04*s*.43.

TABLE III.

Difference of longitude between Frontera and San Elceario, by flashes of gunpowder, made on the 14th February, 1852.

No. of flash.	Name of station.	Name of chronometer.	Time of flash by chronometer.	Chronometer, fast or slow, of mean solar or sidereal time.	Mean solar time of flash at each station.	Difference of longitude.
			h. m. s.		h. m. s.	m. s.
1	Frontera	P. & F. 2440 sidereal	5 07 32.8	Sidereal chronometer 2440 fast of sidereal time at Frontera, derived from its error on the 10th and 18th, m. s. 27 52.08	7 02 40.36	1 07.24
	San Elceario	C. Y. 76 solar	7 01 12.0	Mean solar chronometer 76 slow of mean time at San Elceario, 2 35.60	7 03 47.60	
2	Frontera	2440 sidereal	5 09 31.0		7 04 38.24	*1 06.26
	San Elceario	76 solar	7 03 09.9		7 05 44.50	
3	Frontera	2440 sidereal	5 11 46.5		7 06 53.37	1 07.63
	San Elceario	76 solar	7 05 25.4		7 08 01.00	
4	Frontera	2440 sidereal	5 13 30.5		7 08 37.09	1 06.91
	San Elceario	76 solar	7 07 08.4		7 09 44.00	
5	Frontera	2440 sidereal	5 15 31.3		7 10 37.56	1 07.24
	San Elceario	76 solar	7 09 09.2		7 11 44.80	
6	Frontera	2440 sidereal	5 20 31.3		7 15 36.74	1 07.06
	San Elceario	76 solar	7 14 08.2		7 16 43.80	
7	Frontera	2440 sidereal	5 22 32.0		7 17 36.87	1 07.43
	San Elceario	76 solar	7 16 08.7		7 18 44.30	
8	Frontera	2440 sidereal	5 24 34.3		7 19 39.07	1 07.13
	San Elceario	76 solar	7 18 10.6		7 20 46.20	
9	Frontera	2440 sidereal	5 26 32.8		7 21 37.25	1 07.05
	San Elceario	76 solar	7 20 08.7		7 22 44.30	
10	Frontera	2440 sidereal	5 28 32.3		7 23 36.42	1 06.92
	San Elceario	76 solar	7 22 07.8		7 24 43.40	
11	Frontera	2440 sidereal	5 33 34.8		7 28 38.10	1 07.30
	San Elceario	76 solar	7 27 09.8		7 29 45.40	
12	Frontera	2440 sidereal	5 35 32.8		7 30 35.77	1 06.99
	San Elceario	76 solar	7 29 07.16		7 31 42.76	
13	Frontera	2440 sidereal	5 37 33.8		7 32 36.45	1 07.07
	San Elceario	76 solar	7 31 07.92		7 33 43.52	
14	Frontera	2440 sidereal	5 39 34.6		7 34 36.92	1 07.08
	San Elceario	76 solar	7 33 08.4		7 35 44.00	
15	Frontera	2440 sidereal	5 41 47.3		7 36 49.25	*1 06.75
	San Elceario	76 solar	7 35 20.4		7 37 56.00	

* Reject.

Difference of longitude deduced from 13 flashes of gunpowder, February 14 .... m. s. 1 07.15

TABLE III—Continued.

Difference of longitude between Frontera and San Elceario, by flashes of gunpowder, made on the 18th February, 1852.

No. of flash.	Name of station.	Name of chronometer.	Time of flash by chronometer.	Chronomete, fast or slow, of mean solar or sidereal time.	Mean solar time of flash at each station.	Difference of longitude.
			h. m. s.		*h. m. s.*	*m. s.*
1	Frontera	P. & F. 2440 sidereal	5 25 02.6	Sidereal chronometer 2440 is fast sidereal time at Frontera ... *m. s.* 28 09.46	7 04 06.33	1 07.17
	San Elceario	C. Y. 76 solar	7 02 40.30	Mean solar chronometer 76 slow of mean time at San Elceario ... 2 33.00	7 05 13.50	
			7 02 40.2 *d*			
2	Frontera	2440 sidereal	5 27 02.5		7 06 05.90	1 07.77
	San Elceario	76 solar	7 04 40.4		7 07 13.67	
			L. 40.8			
			C. 40.8			
3	Frontera	2440 sidereal	5 29 27.0		7 08 30.17	1 07.53
	San Elceario	76 solar	7 07 04.6		7 09 37.70	
			7 07 00.8 *d*			
4	Frontera	2440 sidereal	5 31 08.5		7 10 06.41	1 07.7
	San Elceario	76 solar	7 08 41.2		7 11 14.20	
			7 08 41.2			
5	Frontera	2440 sidereal	5 33 04.8		7 12 07.38	1 07.45
	San Elceario	76 solar	7 10 41.9		7 13 14.83	
			7 10 41.9			
			7 10 41.7			
6	Frontera	2440 sidereal	5 38 04.9		7 17 06.66	1 07.54
	San Elceario	76 solar	7 15 41.2		7 18 41.20	
			7 15 41.2			
			7 15 41.2			
7	Frontera	2440 sidereal	5 40 05.5		7 19 06.93	1 07.27
	San Elceario	76 solar	7 17 41.2		7 20 14.20	
			7 17 41.2			
			7 17 41.2			
8	Frontera	2440 sidereal	5 42 05.6		7 21 06.55	1 07.60
	San Elceario	76 solar	7 19 41.16		7 22 14.15	
			7 19 41.2			
			7 19 41.1			
9	Frontera	2440 sidereal	5 44 05.8		7 23 06.42	1 07.78
	San Elceario	76 solar	7 21 41.2		7 24 14.20	
			7 21 41.2			
			7 21 41.2			
10	Frontera	2440 sidereal	5 46 06.8		7 25 07.09	1 07.38
	San Elceario	76 solar	7 23 41.5		7 26 14.47	
			7 23 41.5			
			7 23 41.4			
11	Frontera	2440 sidereal	5 51 07.3		7 30 06.76	1 07.44
	San Elceario	76 solar	7 28 41.2		7 31 14.20	
			7 28 41.2			
			7 28 41.2			
12	Frontera	2440 sidereal	5 53 07.5		7 32 06.63	1 07.57
	San Elceario	76 solar	7 30 41.2		7 33 14.20	
			7 30 41.2			
			7 30 41.2			
13	Frontera	2440 sidereal	5 55 07.8		7 34 06.60	1 07.50
	San Elceario	76 solar	7 32 41.1		7 35 14.10	
			7 32 41.1			
			7 32 41.1			
14	Frontera	2440 sidereal	5 57 08.3		7 36 06.77	1 07.63
	San Elceario	76 solar	7 34 41.4		7 37 14.40	
			7 34 41.4			
			7 34 41.4			
5	Frontera	2440 sidereal	5 59 08.4		7 38 06.55	1 07.65
	San Elceario	76 solar	7 36 41.2		7 39 14.20	
			7 36 41.2			
			7 36 41.2			

Mean difference of longitude by 15 flashes of gunpowder, February 18.............. 1m. 07.54s.

TABLE III—Continued.

Difference of longitude between Frontera and San Elceario, by flashes of gunpowder, made on the 19th of February, 1852.

No. of flash.	Name of station.	Name of chronometer.	Time of flash by chronometer.	Chronometer, fast or slow, of mean solar or sidereal time.	Mean solar time of flash at each station.	Difference of longitude.
			h. m. s.		h. m. s.	m. s.
1	Frontera	P. & F. 2440 sidereal	5 28 06.3	Sidereal chronometer 2440 is fast of sidereal time at Frontera ... m. 28 s. 14.43	7 03 08.67	*1 04.99
	San Elceario	C. Y. 76 solar	7 01 41.3d	Solar chronometer 76 is slow of mean time at San Elceario ... 2 32.6	7 04 13.66	
2	Frontera	2440 sidereal	5 30 08.3		7 05 10.33	1 07.63
	San Elceario	76 solar	7 03 45.6		7 06 17.96	
			7 03 43.6d			
3	Frontera	2440 sidereal	5 32 09.4		7 07 11.10	1 07.29
	San Elceario	76 solar	7 05 46.0		7 08 18.39	
			7 05 46.0			
			7 05 46.1			
4	Frontera	2440 sidereal	5 34 09.2		7 09 10.68	1 07.27
	San Elceario	76 solar	7 07 45.5		7 10 17.95	
			7 07 45.6			
			7 07 45.6			
5	Frontera	2440 sidereal	5 36 09.8		7 11 10.95	1 07.41
	San Elceario	76 solar	7 09 46.0		7 12 18.36	
			7 09 46.0			
			7 09 46.0			
6	Frontera	2440 sidereal	5 41 10.8		7 16 11.12	1 07.54
	San Elceario	76 solar	7 14 46.3		7 17 18.66	
			7 14 46.3			
			7 14 46.3			
7	Frontera	2440 sidereal	5 43 10.6		7 18 10.70	1 07.36
	San Elceario	76 solar	7 16 45.6		7 19 18.06	
			7 16 45.6			
			7 16 45.8			
8	Frontera	2440 sidereal	5 45 10.8		7 20 10.57	1 07.42
	San Elceario	76 solar	7 18 45.6		7 21 17.99	
			7 18 45.6			
			7 18 45.7			
9	Frontera	2440 sidereal	5 47 12.5		7 22 11.94	1 07.22
	San Elceario	76 solar	7 20 46.72		7 23 19.16	
			7 20 46.8			
			7 20 46.8			
10	Frontera	2440 sidereal	5 49 11.8		7 24 10.91	1 07.45
	San Elceario	76 solar	7 22 46.0		7 25 18.36	
			7 22 46.0			
			7 22 46.0			
11	Frontera	2440 sidereal	5 54 51.3		7 29 49.29	1 07.07
	San Elceario	76 solar	7 28 24.0		7 30 56.36	
12	Frontera	2440 sidereal	5 56 12.8		7 31 10.56	1 07.40
	San Elceario	76 solar	7 29 45.6		7 32 17.96	
			7 29 45.6			
			7 29 45.6			
13	Frontera	2440 sidereal	5 58 14.6		7 33 12.03	1 07.54
	San Elceario	76 solar	7 31 47.2		7 34 19.57	
			7 31 47.2			
			7 31 47.2			
14	Frontera	2440 sidereal	6 00 13.3		7 35 10.41	1 07.38
	San Elceario	76 solar	7 33 45.4		7 36 17.79	
			7 33 45.5			
			7 33 45.4			
15	Frontera	2440 sidereal	6 02 14.3		7 37 11.08	1 07.13
	San Elceario	76 solar	6 35 47.7*		7 38 18.21	
			6 35 45.9			
			6 35 45.8			

* Rejected.

Mean difference of longitude by 15 flashes of gunpowder, February 19, 1m. 07s.36.

TABLE III—Continued.

Difference of longitude between Frontera and San Elceario, by flashes of gunpowder, made on the 14th March, 1852.

No. of flash.	Name of station.	Name of chronometer.	Time of flash by chronometer.	Chronometer, fast or slow, of mean solar or sidereal time.	Mean solar time of flash at each station.	Difference of longitude.
			h. m. s.		*h. m. s.*	*m. s.*
1	Frontera	P. & F. 2440 sidereal	7 01 06.8	*m. s.* 30 05.33 Sidereal chronometer 2440 fast of sidereal time at Frontera	6 59 41.57	1 07.44
	San Elceario	C. Y. 76 solar	L. 6 58 36.0	2 13.11 Mean solar chronometer 76 slow of mean time at San Elceario	7 00 49.01	
			C. 6 58 35.8			
2	Frontera	2440 sidereal	7 03 07.4		7 01 41.64	1 07.27
	San Elceario	76 solar	L. 7 00 36.0		7 02 49.11	
			C. 7 00 36.0			
3	Frontera	2440 sidereal	7 05 07.5		7 03 41.62	1 07.09
	San Elceario	76 solar	L. 7 02 35.6		7 04 48.71	
			C. 7 02 35.6			
4	Frontera	2440 sidereal	7 07 08.2		7 05 41.99	1 07.12
	San Elceario	76 solar	L. 7 04 36.0		7 06 49.11	
			C. 7 04 36.0			
5	Frontera	2440 sidereal	7 09 08.5		7 07 41.96	1 06.65
	San Elceario	76 solar	L. 7 06 35.5		7 08 48.61	
			C. 7 06 35.5			
6	Frontera	2440 sidereal	7 14 08.8		7 12 41.56	1 07.20
	San Elceario	76 solar	L. 7 11 35.6		7 13 48.76	
			C. 7 11 35.7			
7	Frontera	2440 sidereal	7 16 09.5		7 14 41.94	1 07.12
	San Elceario	76 solar	L. 7 13 36.0		7 15 49.06	
			C. 7 13 35.9			
8	era	2440 sidereal	7 18 09.5		7 16 41.61	1 07.10
	San Elcearia	76 solar	L. (Lost.)		7 17 48.71	
			C. 7 15 35.6			
9	Frontera	2440 sidereal	7 [illegible] 09.6		7 18 41.37	1 07.29
	San Elceario	76 solar	7 17 35.6		7 19 48.66	
			7 17 35.5			
10	Frontera	2440 sidereal	7 22 10.3		7 20 41.74	1 07.37
	San Elceario	76 solar	L. 7 19 36.0		7 21 49.11	
			C. 7 19 36.0			
11	Frontera	2440 sidereal	(Lost.)		(Lost.)	
	San Elceario	76 solar	L. 7 24 36.0		7 26 49.11	
			C. 7 24 36.0			
12	Frontera	2440 sidereal	7 29 11.2		7 27 41.38	1 06.93
	San Elceario	76 solar	L. 7 26 [illegible]		7 28 48.31	
			7 26 35.2			
13	Frontera	2440 sidereal	7 31 11.6		7 29 41.45	1 07.26
	San Elceario	76 [illegible]	L. 7 28 35.6		7 30 48.71	
			C. 7 28 35.8			
14	Frontera	2440 sidereal	7 33 12.3		7 31 41.82	1 07.09
	San Elceario	76 solar	L. 7 30 35.8		7 32 48.91	
			C. 7 30 35.8			
15	Frontera	2440 sidereal	7 [illegible] 13.4		7 33 42.59	1 07.27
	San Elceario	76 solar	L. 7 32 36.7		7 34 49.86	
			C. 7 32 36.8			

Mean of 14 observations, March 14, 1852 = 1m. 07.15s.

The record of the flashes, to establish the difference of longitude between Frontera and San Elceario, is given as a means of determining the weight to be attached to this mode of observing. Assuming the result to be correct, it gives a very satisfactory coincidence between the results obtained for longitude at Frontera and San Elceario, by moon culminations, by two independent positions, with different instruments and different observers.

The record is omitted for other stations, but the results are given in the following table:

TABLE IV.

Recapitulation of differences of longitude of several astronomical stations on the Rio Bravo, found by flashes of gunpowder.

Date.	No. of flashes.	Difference of long. between Frontera & El Paso.	No. of flashes.	Difference of long. between Frontera & San Elceario.	Difference of long. betweeen El Paso & San Elceario.	No. of flashes.	Difference of long. between San Elceario and mouth of Cañon.
1852.		*s.*		*m. s.*	*s.*		*m. s.*
Feb. 14	14	16.03	13	1 07.16	51.13		
18	15	16.06	15	1 07.54	51.48		
19	12	15.84	15	1 07.36	51.52		
Mar. 14	12	15.84	14	1 07.15	51.31		
June 21	..	.....	..	....	.....	13	2 36.01

TABLE V.

Long. of station near Presidio del Norte, computed from observations with transit, by W. H. Emory.

With tabular R. A. in Nautical Almanac.			With Greenwich observed R. A.		
1852.		*h. m. s.*	1852.		*h. m. s.*
July 26	Observations on moon's 1st limb..........	= 6 57 18.17	July 26	Observations on moon's 1st limb..........	= 6 57 37.53
27	..........do..........do..........	= 27.32	27	..........do..........do..........	= 47.67
28	..........do..........do..........	= 37.41	28	..........do..........do..........	= 55.76
29	..........do..........do..........	= 17.00	29	..........do..........do..........	= 34.50
Aug. 24	..........do..........do..........	= 24.76	Aug. 24	..........do..........do..........	= 44.76
25	..........do..........do..........	= 17.56	25	..........do..........do..........	= 39.02
27	..........do..........do..........	= 06.04	27	..........do..........do..........	= 41.35
28	..........do..........do..........	= 03.41	28	..........do..........do..........	= 20.30
	Sum..........................	= 8)151.67		Sum..........................	= 8)320.89
	Mean..........................	= 6 57 18.96		Mean..........................	= 6 57 40.11
July 30	Observations on moon's 2d limb..........	= 6 57 22.82	July 30	Observations on moon's 2d limb..........	= 6 57 39.66
31	..........do..........do..........	= 11.67	31	..........do..........do..........	= 28.78
Aug. 1	..........do..........do..........	= 35.48	Aug. 1	..........do..........do..........	= 43.27
2	..........do..........do..........	= 06.73	2	..........do..........do..........	= 32.89
3	..........do..........do..........	= 25.13	3	..........do..........do..........	= 40.42
4	..........do..........d..........	= 36.06	4	..........do..........do..........	= 47.38
29	..........do..........do..........	= 08.70	29	..........do..........do..........	= 33.10
	Sum..........................	= 7)146.59		Sum..........................	= 7)265.50
	Moon's 2d limb—mean..........	= 6 57 20.94		Moon's 2d limb—mean..........	= 6 57 37.93
	Moon's 1st limb—mean..........	= 6 57 18.96		Moon's 1st limb—mean..........	= 6 57 40.11
	Sum..........................	= 39.90		Sum..........................	= 78.04
	Mean..........................	= 6 57 19 95		Mean..........................	= 6 57 39.02
	Correction to be applied for tabular error.	= +11.26			
				Long. of station near Presidio del Norte.	= 6 57 39.02
	Long. of station near Presidio del Norte, computed with elements from N. A...	= 6 57 31.21			

TABLE V—Continued.

Comparison of results for longitude of station near Presidio del Norte, for each date of observation, as computed with Tab. R. A. in Nautical Almanac and Greenwich observations.

Date of observation.	Long. computed with N. Almanac R. A.	Long. computed with Greenwich observations.	Greenwich observations + N. Almanac, or difference.
1852.	h. m. s.	h. m. s.	s.
July 26.......	6 57 18.17	6 57 37 53	+ 19.36
27.......	27.32	47.67	20.35
28.......	37.41	55.76	18.35
29.......	17.00	34.50	17.50
30.......	22.82	39.66	16.84
31.......	11.67	28.78	17.11
Aug. 1.......	35.48	43.27	7.79
2.......	06.73	32.89	26.16
3.......	25.13	40.42	15.29
4.......	36.06	47.38	11.32
24.......	24.76	44.76	20.00
25.......	17.56	39.02	21.46
27.......	06.04	41.35	35.31
28.......	03.41	20.30	16.89
29.......	6 57 08.70	6 57 33.10	+ 24.40
	Sum....................................		= 15)288.13
	Mean....................................		= + 19s.21

Comparison of mean results for longitude, obtained from observations on moon's limbs, as computed with Tab. R. A. in Nautical Almanac and Greenwich observations.

	h. m. s.
FIRST.	
Mean of results of observations on moon's first limb, computed from Tabular Right Ascensions in Nautical Almanac..............	6 57 18.96
Mean of results of observations on moon's first limb, computed from Greenwich observations..............................	6 57 40.11
Difference, or Greenwich observations + Nautical Almanac..	= + 21.15
SECOND.	
Mean of results of observations on moon's second limb, computed from Tabular Right Ascensions in Nautical Almanac............	6 57 20.94
Mean of results of observations on moon's second limb, computed from Greenwich observations..............................	6 57 37.93
Difference, or Greenwich observations + Nautical Almanac..	= + 16.99

Corrections to be applied to results obtained from computations (with tabular R. A. in Nautical Almanac) of observations made near Presidio del Norte.

	h. m. s.
Observed difference of longitude between Greenwich and Cambridge, July 28..............................	= 4 44 19.06
Established longitude of Cambridge, west of Greenwich..	= 4 44 29.60
Observed longitude east of established longitude..	10.54
Observed difference of longitude between Greenwich and Cambridge, August 24..............................	= 4 44 17.62
Established longitude of Cambridge, west of Greenwich..	= 4 44 29.60
Observed longitude east of established longitude..	11.98
Difference, July 28..	= 10.54
Do....Aug. 24..	= 11.98
Sum..	= 22.52
Mean correction to be applied..	+ 11.26

TABLE V—Continued.

RECAPITULATION.

Difference of results for longitude of station near Presidio del Norte, as obtained from computations of observed moon culminations, with tabular R. A. in Nautical Almanac and Greenwich observations, 1852.

		h. m. s.
Longitude computed from tabular R. A. in Nautical Almanac	=	6 57 19.95
Longitude computed from Greenwich observations	=	6 57 39.02
Difference between Nautical Almanac and Greenwich observations	=	19.07
Observed longitude of Cambridge *east* of established longitude	=	11.26
Difference	=	7.81
Longitude computed from tabular R. A. in Nautical Almanac, with corrections applied	=	6 57 31.21
Longitude computed from Greenwich observations	=	6 57 39.02
Difference	=	7.81
Longitude of station near Presidio del Norte	=	6 57 39.02

TABLE VI.

Tabulation of results for longitude of astronomical station near Fort Duncan, derived from observations made with 30-inch transit (by Troughton & Simms) and sidereal chronometer No. 2440, *(by Parkinson & Frodsham:) By J. H. Clark, under the direction of Major W. H. Emory, Chief Astronomer and Surveyor of United States and Mexican boundary survey.*

Date.	Authority for elements used.	Moon's 1st limb.	Resulting longitude from observations on moon's 1st limb.	Date.	Authority for elements used.	Moon's 2d limb.	Resulting longitude from observations on moon's 2d limb.
1852.		h. m. s.	h. m. s.	1852.		h. m. s.	h. m. s.
Oct. 19	G. observations..	....	6 42 06.7	Oct. 27	G. observations..	....	6 41 46.2
20	.......do.........	....	12.4	28	.......do.........	....	6 42 01.3
21	.......do........	6 42 00.5	6 41 57.25	29	.......do.........	....	6 41 53.3
21	C. observations..	6 41 54.0		30	.......do.........	....	6 42 04.4
22	G. observations..	6 42 09.5	6 42 06.90	31	.......do.........	....	6 42 02.6
22	C. observations..	04.3		Nov. 1	.......do.........	....	6 42 04.9
23	G. observations .	6 41 58.2	6 41 57.70	2	.......do.........	....	6 41 46.5
23	C. observations..	57.2					
25	G. observations..	6 42 09.5	6 42 07.60				
25	C. observations.	05.7					
26	G. observations..	18.0	6 42 15.65				
26	C. observations..	13.3					
27	G. observations..	....	6 41 49.1				
Mean longitude from moon's 1st limb = 6*h*. 42*m*. 04*s*.16.				Mean longitude from moon's 2d limb = 6*h*. 41*m*. 57*s*.03			

By giving double weight to the results of observations on moon's 1st limb, we have longitude = 6*h*. 42*m*. 01*s*.78

Longitude of astronomical station near Fort Duncan = 6*h*. 42*m*. 01*s*.78

TABLE VII.

Tabulation of results for longitude of astronomical station at Ringgold barracks, derived from observations made with 30-*inch transit (maker unknown) and sidereal chronometer No.* 2440, *(by Parkinson & Frodsham:) By Major W. H. Emory, Chief Astronomer and Surveyor of United States and Mexican boundary survey, assisted by G. C. Gardner and J. H. Clark.*

Date.	Authority for elements used.	Moon's limb observed.	Resulting longitude.
1853.			*h. m. s.*
June 17	Greenwich observations	First	6 35 05.90
18	Philadelphia High School	...do	03.42
20	......do.........do	Second	03.36
25	Greenwich observations	...do	08.39
July 14	......do.........do	First	02.61
15	......do.........do	...do	10.49
16	......do.........do	...do	07.41
18	Philadelphia High School	...do	07.98

Longitude of Ringgold barracks = 6*h.* 35*m.* 06*s*.19.

Discussion of the longitude of astronomical station (g) near the mouth of the Rio Bravo del Norte.

OFFICE OF SURVEY OF UNITED STATES AND MEXICAN BOUNDARY,
Washington, D. C., February 9, 1856.

SIR: In presenting to you the final results of the computations for the longitude of the astronomical station established under your direction in 1853, near the mouth of Rio Bravo del Norte, I have been delayed for want of all the corresponding moon culminations observed at Greenwich throughout the four lunations.

The observations which were commenced by yourself and continued by Messrs. G. C. Gardner and J. H. Clark, extend through four lunations, commencing August 12, and ending November 22, 1853. The longitude resulting from the first three lunations was computed by Mr. C. N. Thom from corresponding observations at Greenwich observatory, furnished in manuscript, in 1853, by Professor Airy, astronomer royal, as well as from the corresponding observations made at Philadelphia High School observatory during the same period—giving for the position of the astronomical station, in longitude, 6*h.* 28*m.* 30*s*.5 west from Greenwich observatory.

Having recently received the printed observations of 1853, made at Greenwich and Radcliffe observatories, the observations of the fourth lunation have also been computed by Mr. Thom, and the results combined with those previously deduced from the first three lunations, without producing any change in the result hitherto adopted, as above given.

The instruments used at this station were a 46-inch transit, made by Troughton & Simms, of London, and an excellent sidereal box-chronometer, made by Parkinson & Frodsham. The transit was mounted on a massive brass stand, which rested on a pine log, imbedded about eight feet in the sand, the whole sheltered by a temporary wooden structure.

The accompanying tables, marked A, exhibit all the observations in detail, with the corrections for instrumental errors as applied, together with the several results deduced from the observations of each night. The tables marked B, C, D, exhibit the computations of those instrumental errors, with their adopted results, as follows:

1. The computed values of the equatorial intervals of each wire from the middle wire—the illumination being east—are (see table B):

I.	II.	III.	IV.	V.	VI.	VII.
$51^s.13$	$34^s.03$	$17^s.09$	$00^s.00$	$17^s.19$	$34^s.14$	$51^s.32$

with a probable error for each value of $\pm 0^s.005$. The equatorial reduction of the mean of the seven wires to the middle wire $= - 0^s.06 \pm 0.00$.

2. The computed value of the error of collimation of the middle wire, as deduced from a mean of twenty-five observations, made on the nights of October 27, 28, and 29, (see table C,) is $= + 0^s.16 \pm 0^s.01$; hence the collimation of the mean of wires, $= + 0^s.10 \pm 0^s.01 =$ (in arc) $+1''.5 \pm 0''.1$.

This value for the collimation of mean of wires has been applied to all the observations of the four lunations, in consideration of the improbability of any perceptible change in that element of the instrumental errors, due to the superior mechanism of the instrument.

3. The azimuthal deviation, howeve r, ha be applied to the observations of each night, a then observed, on account of the unavoidable instability of the foundation of the instrument stand, and shown by the changes of deviation exhibited in column 13 of table A.

4. The equatorial value of the divisions marked on the level used with this instrument has been determined from observations made August 19, 1853, the result being $= 1''.065$ (in arc) for one division (see table D.)

The chronometer rate adopted was obtained by reducing to 0^h sidereal time the error for each night by interpolation; and although the rate therefrom deduced is very satisfactory and regular for the period of any one lunation, it perceptibly continues to increase throughout the series, being for the

First lunation, in August....................................	$= + 1^s.18$
Second lunation, in September............................	$= + 1^s.70$
Third lunation, in October................................	$= + 2^s.89$
Fourth lunation, in November............................	$= + 4^s.60$

In reducing the observations, therefore, the actual rate for the day of observation has been used, as shown in column 18 (table A) of the tabulated computations.

In applying the corrections due to errors of collimation, level, and azimuth, the tables marked E have greatly facilitated the reduction—all which are combined in column 15 (table A) of the tabulated computations, showing the "corrected transits" of stars.

The value for "sidereal time of moon's semi-diameter passing meridian of station," shown in column 19, (table A,) has been computed by interpolation, and applied to corrected transit of the limb observed, giving the corrected transit of its centre; which element has been used in computing, by interpolation, the change of the moon's position.

The positions of the moon, as observed with the transit circle at Greenwich observatory, have served to give, by interpolation, its position for all the nights on which it was observed at the mouth of the Rio Bravo, furnishing reliable and satisfactory results; and these positions were adopted in preference to those deduced from the altazimuth observations, which differ in most cases from those actually observed by the transit circle. The positions adopted, as well as those observed at Philadelphia High School and Radcliffe observatories, during the period stated, are given in table F, being the data used in computing the longitude.

The several results for longitude, computed from the observations of each night, are exhibited in table G; the mean of which is $6^h\ 28^m\ 30^s.48 \pm 0^s.56$, being deduced from forty observations combined with the Greenwich observations, ten with Philadelphia High School, and four with

Radcliffe observations, in which equal weight is given to the results deduced from the Greenwich and Radcliffe observations; whilst double weight has been given to those deduced from Philadelphia High School observations, in consideration of its relative distance from the mouth of Rio Bravo, rendering the moon's position, as observed at Philadelphia High School observatory, so much more reliable than that deduced from Greenwich observations, wherein the law of its motion has not been strictly applied.

The probable error, whilst it may furnish an approximate estimate of the value of the result of any one series, cannot certainly be a very reliable guide, unless applied to a continued series of observations, made under various changes of condition, such as may eliminate all possible or probable errors to which observations are subjected.

In the results tabulated I have therefore introduced all such as appear reliable, giving to each its estimated value in the final result, without any regard to its "probable error," as it does not appear what personal or other constant errors may have crept into any or all the observations which have been combined in the computations. In adopting this plan, I am glad to find myself sustained by a paper in the "Astronomical Journal," of January 9, 1856, over the signature of Professor Airy, astronomer royal.

I have therefore to recommend that, until corrected by the application of more accurate laws of the moon's motion, or additional observations, that $6^h\ 28^m\ 30^s.5$ should continue to be adopted for the longitude of the astronomical station, west from the meridian of Greenwich observatory.

Very respectfully, your obedient servant,

GEORGE THOM,
Captain Topographical Engineers.

Major W. H. EMORY, *United States Commissioner.*

NOTE.—By way of experiment, the accompanying tables, marked H, I, and K, are presented, exhibiting the results combined in different ways, without, as it appears, materially changing the result given above.

1. In table H, showing the results of the moon's limbs separately combined—giving to those results their relative values adopted for each night, (as in table G,) the mean of I and II limbs being ... $= 6h.28m.30s.52$
2. In table I, showing those results deduced from actual corresponding observations only, and giving to those results their relative values adopted for each night, the mean of the whole being ...... $= 6h.28m.30s.38$
3. In table K, showing the results deduced from actual corresponding observations only, of each limb separately combined—giving to those results their relative values adopted for each night—a mean of the two limbs being .... $= 6h.28m.30s.45$

GEORGE THOM,
Captain Topographical Engineers.

TABLE A.

Meridian transit observations made at mouth of the Rio Grande with 46-inch transit, (by Troughton & Simms,) and sidereal chronometer No. 2440, (by Parkinson & Frodsham,) and computations of apparent right ascension and longitude deduced therefrom. By G. C. Gardner and J. H. Clark, obs'rs; C. N. Thom, comp.

Date.	No. for reference.	Name of object.	Illuminated end of axis.	Seconds of transit over the seven wires. I.	II.	III.	IV.	V.	VI.	VII.	Concluded transit over the mean of the seven wires.	Error of— Collima'n, (azimuth.)	Level.	Corrected transit.	Tabular right ascension of known stars and moon's centre.	Chronometer apparently fast of sider'l time.	Adopted chronometer fast at 0h. sider'l time and (gaining rate.)	Sidereal time of semi-diam. passing meridian of station.	Apparent right ascension of centre deduced from observations made at Royal Observ., Greenwich.	Long. west of Greenwich deduced from observations of each night.
1853.				s.	s.	s.	s.	s.	s.	s.	h. m. s.	"	"	h. m. s.	h. m. s.	h. m. s.	m. s.	m. s.	h. m. s.	h. m. s.
Aug. 12	1	Moon's 1st limb.	E.	......	......	16.2	34.8	53.3	12.0	30.6	17 44 34.72	+ 2.44 (— 5.59)	+ 1.65	17 44 34.72	15.44 24.73	....	45 28.00	1 11.56	15 44 14.26	6 28 35.04
	2	ψ Ophiuchi		04.6	22.8	41.2	59.3	17.4	35.3	53.6	18 00 59.17	+ 1.50	1.65	18 00 59.08	16 15 31.72	1 45 27.36	(+ 1.00)	....	....	....
	3	α Scorpii		55.8	14.8	34.2	53.0	11.8	30.7	50.2	18 05 52.93	— 1.59	1.65	18 05 52 80	16 20 25.54	1 45 27.26		....	....	....
	4	G. C. 1402		06.6	27.2	47.5	08.4	28.8	49.4	10.3	18 26 08.31		1.65	18 26 08.11	16 40 40.81	1 45 27.30		....	....	....
	5	G. C. 1418		19.3	36.8	54.2	11.4	28.6	45.8	03.3	18 36 11.34		+ 1.65	18 36 11.24	16 50 44.17	1 45 27.07		....	....	....
13	6	Moon's 1st limb.	E.	28.6	47.7	06.8	26.0	45.2	04.2	23.3	18 46 25.97	+ 1.50	+ 4.81	18 46 25.85	16 45 08.76	....	....	1 13.62	16 45 08.12	6 28 40.00
	7	θ Ophiuchi		34.3	53.2	11.8	30.8	49.5	08.3	27.2	18 58 30.73	(— 8.93)	4.81	18 58 30.55	17 13 00.89	1 45 29.66	45 30.06	....	17 13 00.91	....
	8	b Ophiuchi		59.6	18.3	36.8	55.5	14.2	32.7	51.6	19 02 55.53		4.74	19 02 55.36	17 17 25.50	1 45 29.85	(+ 2.25)	....	17 17 25.48	....
	9	G. C. 1532		11.4	28.6	45.5	02.6	20.2	36.8	54.3	19 26 02.77		4.40	19 26 02.81	17 40 32.93	1 45 29.88		....	....	....
	10	γ Draconis		19.5	46.8	14.4	42.2	09.4	36.6	04.3	19 38 41.89		4.40	19 38 42.88	17 53 13.37	1 45 29.51		....	....	....
	11	G. C. 1575		02.3	19.7	37.2	54.3	11.6	28.8	46.4	19 45 54.33		+ 4.40	19 45 54.54	18 00 25.26	1 45 29.28		....	....	....
15	12	ν¹ Sagittarii	W.	58.2	16.5	34.6	53.3	12.2	30.3	48.6	20 30 53.39	— 1.50	+ 0.82	20 30 52.85	18 45 19.73	1 45 33.12	45 33.40	....	....	....
	13	ξ² Sagittarii		......	56.8	14.4	33.3	51.6	09.8	28.3	20 34 33.2	(— 8.59)	0.82	20 34 32.78	18 48 59.55	1 45 33.23	(+ 2.26)	....	....	....
	14	Moon's 1st limb.		12.3	31.9	51.2	10.7	30.3	49.8	09.3	20 57 10.79		0.82	20 57 10.23	18 55 05.69	....		1 14 85	18 55 04.71	6 28 35.91
	15	κ² Sagittarii		24.8	43.8	02.5	21.6	40.3	59.2	18.0	21 13 21.46		0.82	21 13 20.90	19 27 47.78	1 45 33.12		....	....	....
	16	γ Aquilæ		59.4	16.6	34.0	51.6	09.2	26.3	43.3	21 24 51.49		1.11	21 24 51.29	19 39 18.25	1 45 33.04		....	....	....
	17	β Sagittarii		33.7	53.3	11.8	31.2	50.4	09.8	29.3	21 33 31.38		1.29	21 33 30.79	19 47 57.71	1 45 33.08		....	....	....
	18	α² Capricorni		37.3	54.6	11.8	29.4	47.3	04.6	22.3	21 55 29.61		1.84	21 55 29.24	20 09 55.92	1 45 33.32		....	....	....
	19	α Pavonis		03.4	35.0	05.8	37.6	09.6	40.9	12.8	21 59 37.87		+ 1.92	21 59 36.68	20 14 03.48	1 45 33.20		....	....	....
16	20	λ² Sagittarii	E.	26.6	45.4	04.3	22.9	41.8	00.7	19.6	21 13 23.04	+ 1.50	+ 2.20	21 13 22.16	19 27 47.78	1 45 34.38	45 34 58	....	....	....
	21	γ Aquilæ		00.8	18.2	35.3	52.6	10.0	27.3	44.5	21 24 52.67	(— 19.21)	2.20	21 24 52.56	19 39 18.25	1 45 34.31	(+ 0.88)	....	....	....
	22	α Aquilæ		21.5	38.6	55.8	13.2	30.8	47.7	05.3	21 29 13.27		2.20	21 29 13.11	19 43 38.66	1 45 34.45		....	....	....
	23	b Sagittarii		35.4	54.8	13.6	33.0	52.6	12.1	31.2	21 33 33.24		2.20	21 33 32.28	19 47 57.70	1 45 34.58		....	....	....
	24	Moon's 1st limb.		05.3	24.1	43.3	02.6	21.8	41.5	00.3	22 02 02.70		1.65	22 02 01.81	20 00 26.51	....		1 13 45	20 00 25.36	6 28 39.85
	25	ρ Capricorni		12.2	30.0	47.6	05.7	23.8	42.0	59.8	22.06 05.87		1.10	22 06 05.08	20 20 30.56	1 45 34.53		....	....	....
	26	α Cygni		49.2	13.3	37.2	01.3	25.5	49.3	13.4	22 22 01.31		+ 1.10	22 22 02.15	20 36 27.51	1 45 34.64		....	....	....

REMARKS.—Equatorial intervals of each wire from the middle wire, (illumination east.)

I.	II.	III.	V.	VI.	VII.
51s.13	34s 03	17s.09	17s.19	34s.14	51s.32

Equatorial reduction of mean of wires to middle wire.................... = — 0s.06 ± 0s.00

Collimation of middle wire.................... = + 0s.16 ± 0s.01

Collimation of mean of wires.................... = + 0s.10 ± 0s.01 (in arc = + 1″5 ± 0″.1

Meridian transit observations made at mouth of Rio Grande, &c.—Continued.

Date.	Number for reference.	Name of object.	Illuminated end of axis.	Seconds of transit over the seven wires. I.	II.	III.	IV.	V.	VI.	VII.	Concluded transit over the mean of the seven wires.	Error of— Collima'n, (azimuth.)	Level.	Corrected transit.	Tabular right ascension of known stars and moon's centre.	Chronometer apparently fast of sider'l time.	Adopted chronometer fast at 0h. sider'l time and (gaining rate.)	Sidereal time of semi-diam. passing meridian of station.	App. R. A. of centre deduced from observations made at High School Observatory, Phila.	Royal Observatory, Gr'nwich.	Long. west of Greenwich deduced from observations of each night.
				s.	s.	s.	s.	s.	s.	s.	h. m. s.	"	"	h. m. s.	h. m. s.	h. m. s.	m. s.	m. s.	h. m. s.	h. m. s.	h. m. s.
1853. Aug. 17a	27	β Capricorni	W.	30.2	47.6	05.3	22.8	40.8	58.4	16.0	21 58 23.01	— 1.50	+ 0.96	21 58 22.42	20 12 47.15	1 45 35.32	45 35.16	....	....	20 12 47.10	....
	28	ρ Capricorni		12.4	30.6	48.2	06.3	24.3	42.4	00.3	22 06 06.36	(— 12.10)	0.96	22 06 05.72	20 20 30.57	1 45 35.15	(+ 0.37)	....	....	....	....
	29	α Cygni		49.9	13.8	37.6	02.3	26.5	50.0	14.2	22 22 02.01		0.96	22 22 02.31	20 36 27.50	1 45 34.81		....	....	....	....
	30	61[1] Cygni		50.8	12.7	34.3	56.0	17.8	39.3	01.2	22 45 56.01		1.26	22 45 56.20	21 00 20.96	1 45 35.24		....	....	....	....
	31	ξ Cygni		19.0	38.8	58.4	18.5	37.8	57.6	17.0	22 52 18.16		1.34	22 52 18.21	21 06 43.06	1 45 35.15		....	....	....	....
	32	G. C. 1900		47.8	05.8	23.3	41.6	59.4	17.2	35.3	22 59 41.49		1.46	22 59 40.88	21 14 06.32	1 45 34.56		....	....	....	....
	33	Moon's 1st limb.		52.0	11.4	29.9	48.8	07.6	26.2	45.1	23 03 48.71		1.48	23 03 48.05	21 03 08.82	....		1 11.12	....	21 03 07.50	6 28 29.28
	34	Moon's 2d limb.		14.7	38.3	52.3	10.9	30.0	48.6	07.2	23 06 11.07		1.51	23 06 10.41	21 03 08.82	....		1 11.12	....	21 03 07.50	....
	35	ε Pegasi		43.7	01.2	17.8	....	52.8	10.3	27.8	23 22 35.67	— 2.44	1.51	23 22 35.37	21 37 00.18	1 45 35.19		....	....	....	....
	36	δ Capricorni		....	57.8	15.3	33.8	51.3	08.8	26.7	23 24 33.34		1.65	23 24 32.68	21 38 57.68	1 45 34.92		....	....	....	....
	37	μ Capricorni		02.3	19.6	37.3	54.8	12.2	29.7	47.5	23 30 54.77	— 1.50	+ 2.06	23 30 54.25	21 45 18.95	1 45 35.30		....	....	....	....
18	38	δ Capricorni	E.	40.2	58.3	16.0	33.5	51.6	09.3	27.4	23 24 33.76	+ 1.50	+ 2.06	23 24 33.09	21 38 57.69	1 45 35.32	45 35.32	....	....	21 38 57.77	....
	39	[illegible] Gruis		20.6	46.2	11.6	36.7	02.4	27.5	52.7	23 44 36.81	(— 18.67)	2.06	23 44 35.24	21 59 00.10	1 45 35.14	(+ 0.05)	....	....	....	....
	40	Moon's 2d limb.		54.3	12.6	30.5	48.7	07.3	25.4	43.8	24 03 48.94		2.06	24 03 48.28	22 01 57.03	....		1 08.51	....	22 01 55.78	6 28 20.69
	41	σ Aquarii		37.8	55.2	12.4	29.9	47.5	04.8	22.3	24 08 29.99		1.89	24 08 29.43	22 22 54.10	1 45 35.33		....	....	....	....
	42	ζ Pegasi		53.4	10.8	28.2	45.6	03.3	20.2	37.7	24 19 45.60		1.35	24 19 45.44	22 34 10.03	1 45 35.41		....	....	....	....
	43	G. C. 2047		36.2	54.6	13.5	32.3	50.8	09.3	28.3	24 28 32.14		1.00	24 28 32.28	22 42 57.19	1 45 35.09		....	....	....	....
	44	[illegible] Aquarii		35.4	53.6	11.3	28.9	47.0	04.5	22.4	24 32 29.01		0.82	24 32 28.29	22 46 52.88	1 45 35.41		....	....	....	....
	45	α Piscis Australis.		10.5	30.3	50.2	09.6	29.8	49.5	09.3	24 35 09.89		+ 0.68	24 35 08.84	22 49 33.56	1 45 35.28		....	....	....	....
[illegible]	46	σ Aquarii	W.	37.7	55.4	12.6	30.3	47.7	05.2	26.6	24 08 30.21	— 1.50	— 0.27	24 08 29.22	22 22 54.11	1 45 35.11	45 35.28	....	22 22 54.10	....	....
	47	ζ Pegasi		53.6	11.3	28.4	45.8	03.3	20.5	38.0	24 19 45.84	(— 21.45)	0.27	24 19 45.31	22 34 10.04	1 45 35.27	(+ 0.75)	....	....	....	....
	48	δ Aquarii		35.7	53.6	11.2	29.1	47 3	04.8	22.7	24 32 29.20		0.27	24 32 28.08	22 46 52.89	1 45 35.19		....	22 46 52.87	....	....
	49	α Piscis Australis.		10.8	30.7	50.3	10.4	30.5	49.8	09.9	24 35 10.34		0.27	24 35 08.86	22 49 33.58	1 45 35 28		....	....	....	....
	50	α Pegasi		11.3	29.2	46.4	04.3	22.0	39.3	57.2	24 43 04.24		0.27	24 43 03.86	22 57 28.59	1 45 35.27		....	....	....	....
	51	ψ Aquarii		29.0	46.3	03.4	20.6	38 2	55.0	11.9	24 52 20.63		0.27	24 52 19.75	23 06 44.72	1 45 35.03		....	23 06 44.49	....	b 6 28 22.33
	52	Moon's 2d limb.		34.2	51.7	09.5	27.6	45.3	03.3	20.6	24 57 27.46		— 0.27	24 57 26.47	22 56 39.41	....		1 06.08	c 23 07 34.76	22 56 38.29	d 6 28 33.62
[illegible]	53	α Piscis Australis.	[illegible]	12.1	31.8	51.6	11.5	31.3	51.3	11.3	0 35 11.56	+ 1.50	+ 0.82	0 35 10.48	22 49 33.59	1 45 36.69	45 36.81	....	....	....	....
	54	α Pegasi		12.7	30.6	48.2	05.6	23.3	40.8	57.7	0 43 05.70	(—18.19)	— 0.82	9 43 05.50	22 57 28.60	1 45 36.90	(+ 1.42)	....	....	....	....
	55	ϕ Aquarii		30.3	47.6	04.8	21.8	39.5	56.6	13.6	0 52 22.03		0.82	0 52 21.44	23 06 44.74	1 45 36.70		....	....	....	....
	56	ψ[2] Aquarii		06.4	23.6	41.2	58.3	15.9	33.2	50.4	0 56 58.43		0.82	0 56 57.76	23 11 20.86	1 45 36.90		....	....	....	....
	57	33 Piscium		36.7	53.8	11.1	27.8	45.3	02.4	19.8	1 43 28.13		1.81	43 27.48	23 57 50.66	1 45 36.82		....	....	....	....
	58	Moon's 2d limb.		57.3	14.6	32.0	49.6	07.3	24.7	42.2	1 47 49.67		2.06	1 47 49.03	23 47 50.04	....		1 04.30	....	23 47 49.06	6 28 14.71
	59	12 Ceti		20.3	37.6	54.3	11.6	28.8	46.0	02.7	2 08 11.90		— 2.06	2 08 11.26	0 22 34.28	1 45 36.98		....	....	....	....

21	60	33 Piscium	W.	37.8	55.3	12.2	29.4	47.0	03.7	20.9	1 43 28.90	— 1.50	+ 0.13	1 43 28.50	23 57 50.68	1 45 37.82	45 38.11				
	61	α Andromedæ		29.8	49.3	08.6	28.2	47.6	06.7	26.1	1 46 28.04	(— 8.52)	0.13	1 46 27.91	0 00 49.92	1 45 37.99	(+ 1.61)				
	62	12 Ceti		21.6	38.8	55.5	12.7	30.2	47.6	04.3	2 08 12.96		0.13	2 08 12.58	0 22 34.30	1 45 38.28					
	63	20 Ceti		19.1	36.3	52.9	10.3	27.6	44.4	01.8	2 31 10.34		0.22	2 31 09.99	0 45 31.66	1 45 38.33			0 45 31.75		b6 28 27.27
	64	Moon's 2d limb.		02.6	20.2	37.1	54.9	12.5	29.7	47.3	2 35 54.90		0.24	2 35 54.57	0 36 25.73			1 03.20	e0 46 19.72	0 36 24.88	d6 28 35.90
	65	ε Piscium		07.8	25.2	42.3	59.4	16.8	34.0	50.9	2 40 59 49		+ 0.27	2 40 59.22	0 55 21.00	1 45 38.22			0 55 20.96		
[illegible]	66	α Andromedæ	E.	31.8	50.9	10.5	30.0	49.6	08.4	28.2	1 46 29.91	+ 1.50	+ 1.65	1 46 30.18	0 00 49.93	1 45 40.25	45 40.03				
	67	γ Pegasi		29.6	47.3	04.7	22.3	40.3	57.5	15.4	1 51 22.44	(—16.63)	1.65	1 51 22.42	0 05 42.26	1 45 40.16	(+ 1.43)				
	68	θ Ceti		31.2	48.3	05.4	22.7	40.0	57.6	14.8	3 02 22.86		1.59	3 02 22.40	1 16 42.37	1 45 40.03					
	69	G. C. 135		44.7	07.6	30.2	52.4	15.5	37.6	00.5	3 13 52.64		1.37	3 13 53.25	1 28 13.35	1 45 39 90					
	70	ν Piscium		37.6	54.8				03.3	20.8	3 19 29.05	+ 2.44	1.26	3 19 28.89	1 33 48.76	1 45 40.13					
	71	Moon's 2d limb.		54.3	12.1	29.2	46.8	04.3	22.0	39.3	3 22 46.86	+ 1.50	+ 1.23	3 22 46.66	1 23 30.03			1 02.72		1 23 29.32	6 28 27.22
23	72	ο Piscium	W.	39.6	46.8	03.8	21.2	38.7	55.6	12.9	3 23 21.23	— 1.50	+ 2.33	3 23 20.88	1 37 39.91	1 45 40.97	45 40.98				
	73	G. C. 195		04.3	21.6	38.4	55.6	13.3	30.3	47.4	3 50 55.84	(—18.97)	2.33	3 50 55.49	2 05 14.42	1 45 41.07	(+ 1.07)				
	74	Moon's 2d limb.		32.3	50.3	07.7	25.7	43.4	01.0	18.3	4 09 25.53		1.92	4 09 25.24	2 10 05.09			1 02.96		2 10 04.52	6 28 33.54
	f75	B. A. C. 845		51.0	08.6	25.4	42.8	00.3	17.5	34.8	4 22 42.91		1.59	4 22 42.53	2 37 01.52	1 45 41.08				2 37 01.45	
	f76	π Arietis		54.9	12.9	30.6	48.5	06.4	24.2	42.2	4 26 48.53		1.51	4 26 48.32	2 41 07.21	1 45 41.11				2 41 07.21	
24	77	B. A. C. 845	E.	52.2	09.4	26.6	43.8	01.3	18.5	36.3	4 22 44.01	+ 1.50	+ 0.55	4 22 43.83	2 37 01.48	1 45 42.35	45 42.17				
	78	π Arietis		56.1	13.7	31.8	49.3	07.4	25.2	43.2	4 26 49.53	(— 15.72)	0.59	4 26 49.50	2 41 07.24	1 45 42.27	(+ 1.47)			2 41 07.23	
	79	G. C. 251		37.8	56.2	14.3	32.6	50.8	09.0	27.6	4 36 32.61		0.55	4 36 32.66	2 50 50.48	1 45 42.18					
	80	α Ceti		28.8	46.0	02.8	19.9	36.8	54.3	11.5	4 40 20.01		+ 0.24	4 40 19.71	2 54 37.36	1 45 42.35					
	81	ζ Arietis		16.6	34.8	52.8	11.2	29.9	47.6	06.0	4 52 11.27		— 0.37	4 52 11.25	3 06 28.88	1 45 42.40				3 06 28.85	
	82	Moon's 2d limb.		52.2	10.4	27 7	46.3	04.3	22.3	40.2	4 56 46.20		0.99	4 56 46.03	2 57 07.66			1 03.75		2 57 07.07	6 28 32.10
	83	α Persei			41.8	08.4	34.3	00.9	26.6	53.3	4 59 34.38		— 1.23	4 59 35.06	3 13 52.67	1 45 42.39					
Sept. 12g	84	β Lyræ	W.	54.8	15.3	35.8	56.2	16.6	36.8	57.3	20 30 56.11	— 1.50	+ 0.68	20 30 56.01	18 44 40.47	1 46 15.54	46 15.70				
	85	ο Sagittarii		14.7	33.3	51.5	10.0	28.4	46.9	05.2	20 42 10.00	(— 2.42)	0.68	20 42 09.79	18 55 54.03	1 46 15.76	(+ 1.20)				
	86	π Sagittarii		23.8	42.3	00.3	18.7	37.2	55.2	14.3	20 47 18.83		0.68	20 47 18.62	19 01 02.98	1 46 15.64					
	87	δ Aquilæ		31.4	48.6	05.3	22.8	39.6	56.8	14.0	21 04 22.64		0.68	21 04 22.52	19 18 06.85	1 46 15.68					
	88	γ Aquilæ		41.6	59.2	16.0	33.5	50.8	08.3	25.7	21 25 33.59		0.92	21 25 33.50	19 39 18.00	1 46 15.50					
	89	Moon's 1st limb.		54.3	13.7	32.9	52.6	11.8	31.0	50.2	21 39 52.36		1.10	21 39 52.16	19 37 45.84			1 13.30		19 37 45.20	6 28 30.23
	90	σ Capricorni		18.2	36.4	54.2	12.6	30.5	48.5	06.7	21 57 12.44		1.10	21 57 12.27	20 10 56.68	1 46 15.59					
	91	π Capricorni		18.3	36.4	54.0	12.3	30.2	48.4	06.3	22 05 12.27		+ 1.10	22 05 12.11	20 18 56.44	1 46 15.67					
13	92	σ Capricorni	E.	18.8	37.1	55.3	12.8	31.4	49.2	07.7	21 57 13.19	+ 1.50	+ 0.27	21 57 13.03	20 10 56.64	1 46 16.36	46 16.34		20 10 56.41	20 10 56.67	
	93	π Capricorni		18.8	36.8	54.8	12.9	30.8	47.8	06.9	22 05 12.81	(— 5.27)	0.27	22 05 12.66	20 18 56.34	1 46 16.23	(+ 0.67)		20 18 56.29	20 18 56.43	b6 28 30.48
	94	Moon's 1st limb.		27.6	46.7	05.8	21.8	43.8	02.3	21.6	22 41 24.66		0.27	22 41 24.51	20 40 04.07			1 11.31	h20 52 39.82	20 40 03.21	d6 28 30.60
	95	ζ Cygni		00.2	19.8	39.3	58.7	18.8	38.3	57.9	22 52 59.00		0.27	22 52 59.10	21 06 42.92	1 46 16.18					
	96	ξ Capricorni		39.6	58.2	16.6	35.3	53.8	12.3	30.8	23 04 35.23		0.16	23 04 35.06	21 18 18.49	1 49 16.57			21 18 18.22		
	97	β Aquarii		16.4	33.4	50.3	07.6	25.0	42.2	59.5	23 10 07.77		0.11	23 10 07.70	21 23 51.30	1 46 16.40					
	98	ε Capricorni		15.1	33.3	51.4	09.3	27.8	45.8	04.2	23 15 09.56		0.05	23 15 09.40	21 28 53.04	1 46 16.15				21 28 53.25	
	99	G. C. 1931		15.3	09.3	27.3	45.6	03.8	21.6	40.0	23 20 45.56		+ 0.00	23 20 45.40	21 34 29.10	1 46 16 30					

a Moon's second limb imperfect. b Deduced from corresponding observations made at Greenwich Observatory. c + 66.21 = computed time of moon's semi-diam. passing meridian.
d Deduced from corresponding observations made at Phila. High School Observatory. e 63.15s. = computed time of moon's semi-diam. passing meridian. f Cloudy during the observations on Nos. 75 and 76.
g Sept. 12, very hazy. No culmination could be taken previous to this because of the bad weather. h 71s.46 computed time of moon's semi-diameter passing meridian.

Meridian transit observations made at mouth of Rio Grande, &c.—Continued.

Date.	No. for reference.	Name of object.	Illuminated end of axis.	Seconds of transit over the seven wires.							Concluded transit over the mean of the seven wires.	Error of—		Corrected transit.	Tabular right ascension of known stars and moon's centre.	Chronometer apparently fast of sider'l time.	Adopted chronometer fast at 0h. sider'l time and (gaining rate.)	Sidereal time of semi-diam. passing meridian of station.	App. R. A. of centre deduced from observations made at—		Long. west of Greenwich deduced from observations of each night.
				I.	II.	III.	IV.	V.	VI.	VII.		Collima'n, (azimuth.)	Level.						High School Observatory; Phila.	Royal Observatory, Gr'nwich.	
1853.				*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h. m. s.*	"	"	*h. m. s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*	*h. m. s.*	*h m. s.*	*h. m. s.*
Sept. 14*a*	100	ξ Cygni	W.	01.0	20.8	40.3	00.2	19.4	39.3	59.1	22 53 00.10	— 1.50	— 0.68	22 52 59.82	21 06 42.91	1 46 16.91	46 17.04	......	......	......	......
	101	ξ Capricorni		......	59.2	17.3	35.6	54.5	12.8	31.3	23 04 35.94	(— 5.48)	0.68	23 04 35.44	21 18 18.48	1 46 16.96	(+ 1.28)	......	......	......	......
	102	β Aquarii		17.2	34.4	51.3	08.7	25.8	43.0	00.3	23 10 08.67		0.68	23 10 08.34	21 23 51.30	1 46 17.00		......	......	......	......
	103	ε Capricorni		15.9	34.3	52.3	10.8	28.8	47.1	04.7	23 15 10.56		0.68	23 15 10.14	21 28 53.24	1 46 16.90		......	......	......	......
	104	ε Pegasi		25.6	42.8	00.0	17.5	34.8	52.3	09.3	23 23 17.47		0.68	23 23 17.22	21 37 00.19	1 46 17.03		......	......	......	......
	105	μ Capricorni		43.5	01.4	18.7	36.7	54.3	......	......	23 31 36.54		0.73	23 31 36.16	21 45 19.05	1 46 17.11		......	......	......	......
	106	Moon's 1st limb		31.6	50.3	08.4	27.0	45.5	03.8	22.2	23 39 26.97		0.78	23 39 26.57	21 39 03.06	......		1 08.88	......	21 39 01.98	6 28 37.08
	107	ι Aquarii		56.4	14.2	......	......	......	......	......	23 44 49.45		— 0.82	23 44 48.99	21 58 31.99	1 46 17.00		......	......	......	......
15	108	μ Capricorni	E.	......	......	......	37.8	55.7	13.4	31.2	23 31 38.17	+ 1.50	— 0.27	23 31 38.03	21 45 19.05	1 46 18.98	46 18.91	......	......	......	......
	109	ι Aquarii		58.3	15.8	33.3	......	08.8	26.4	44.2	23 44 51.05	(— 6.87)	0.27	23 44 50.90	21 58 31.99	1 46 18.99	(+ 1.93)	......	......	......	......
	110	G. C. 1993		34.2	51.4	08.6	26.0	43.3	00.5	17.7	23 55 25.96		0.27	23 55 25.78	22 09 06.85	1 46 18.93		......	......	......	......
	111	G. C. 2019		......	49.2	09.8	30.2	50.6	10.7	31.5	0 09 30.08		0.27	0 09 29.79	22 23 11.09	1 46 18.70		......	......	......	......
	112	ξ Pegasi		37.3	54.6	12.0	29.2	46.6	03.8	21.3	0 20 29.26		0.22	0 20 29.22	22 34 10.18	1 46 18.94		......	......	......	......
	113	Moon's 1st limb.		54.6	12.3	30.2	48.4	06.3	24 2	42.0	0 33 48.29		0.14	0 33 48.09	22 34 18.61	......		1 06.56	......	22 34 17.31	6 28 37.19
	*b*114	Moon's 2d limb.		06.5	24.4	41.8	00.3	18.3	36.3	53.8	0 36 00.20		0.13	0 36 00.00	22 34 18.61	......		1 06.56	......	22 34 17.31	......
	115	φ Aquarii		......	29.5	46.8	04.3	21.4	38.5	55.6	0 53 03.98		0.13	0 53 03.88	23 06 44.97	1 46 18.91		......	......	......	......
	116	ψ³ Aquarii		48.3	06.0	22.8	40.3	57.7	14.8	32.6	0 57 40.34		— 0.13	0 57 40.16	23 11 21.11	1 46 19.05		......	......	......	......
16	117	φ Aquarii	W.	......	32.3	......	06.5	23.3	40.2	57.6	0 53 06.20	— 1.50	+ 0.82	0 53 05.79	23 06 44.97	1 46 20.82	46 20.98	......	......	......	......
	118	ψ³ Aquarii		50.8	07.8	25.3	42.6	59.8	17.3	34.6	0 57 42.60	(— 8.27)	0.82	0 57 42.21	23 11 21.11	1 46 21.10	(2.20)	......	23 11 21.32	......	*c*6 28 30.72
	119	Moon's 1st limb.		04.5	22.3	39.8	57.4	14.8	32.6	50.3	1 24 57.39		0.82	1 24 57.02	23 26 11.40	......		1 04.68	*d*23 36 38.50	23 26 09.87	*e*6 28 23.86
	120	Moon's 2d limb.		14.2	31.8	49.4	07.1	24.8	42.3	59.6	1 27 07.03		0.82	1 27 06.66	23 26 11.40	......		1 04.68	*d*23 36 38.50	23 26 09.87	......
	121	33 Piscium		......	38.3	55.3	......	......	......	04.2	1 44 12.67		0.95	1 44 12.26	23 57 51.03	1 46 21.05		......	23 57 51.10	23 57 51.21	......
	122	α Andromedæ		13.3	32.6	......	12.0	......	50.2	09.8	1 47 11.58		1.05	1 47 11.46	0 00 50.27	1 46 21.19		......	......	......	......
	123	γ Pegasi		11.2	28.6	46.3	04.0	21.7	39.3	57.0	1 52 04.01		1.23	1 52 03.87	0 05 42.60	1 46 21.27		......	......	......	......
	124	β Ceti		42.5	00.4	18.3	36.8	54 6	12.8	39.8	2 22 36.60		+ 1.23	2 22 36.19	0 36 14.90	1 46 21.29		......	......	......	......
17*f*	125	γ Pegasi	E.	13.2	30.6	48.3	06.0	23.8	41.3	59.3	1 52 06.07	+ 1.50	— 0.41	1 52 06.09	0 05 42.61	1 46 23.48	46 23.31	......	......	......	......
	126	Moon's 2d limb.		59.6	16.8	34.4	51.6	09.2	26.5	44.2	2 15 51.76	(— 3.47)	0.41	2 15 51.34	0 15 27.89	......	(+ 2.45)	1 03.41	......	0 15 26.56	6 28 24.60
	127	β Ceti		44.7	02.8	20.9	38.5	56.8	14.7	33.1	2 22 38.79		0.34	2 22 38.70	0 36 14.92	1 46 23.78		......	......	......	......
	128	20 Ceti		04.3	21.5	38.3	55.7	12.8	29.8	47.2	2 31 55.66		1.24	2 31 55.65	0 45 32.13	1 46 23.44		......	0 45 32.14	0 45 32.21	......
	129	G. C. 62		58.3	18.2	37.5	57.3	......	37.2	......	2 37 57.55		0.17	2 37 57.51	0 51 33.81	1 46 23.70		......	......	......	......
	130	G. C. 66		53.3	10.5	27.6	44.6	02.3	19.3	36.6	2 41 44.89		— 0.13	2 41 44.78	0 55 21.42	1 46 23.36		......	......	......	......
	131	G. C. 121		03.5	20.8	37.7	55.0	12.3	......	46.8	3 08 55.02		+ 0.01	3 08 55.10	1 22 31.48	1 46 23.62		......	......	......	......

18g	132	δ Piscium........	W.	40.7	......	15.3	32.4	49.8	06.3	24.3	2 27 32.48	— 1.50	— [illegible]	[illegible] 32.01	0 41 05.90	1 46 25.96	46 25.89	....	0 41 05.93	0 41 06.05	....
	133	G. C. 66		56.3	13.8	30.8	48.3	[illegible]	[illegible]	39.8	2 41 48.10	(— 7.09)	0.96	2 41 47.78	0 55 21.43	1 46 26.35	(+ 2.81)	....	....	....	c 6 28 29.69
	134	Moon's 2d limb..		[illegible]	39.3	56.6	13.8	[illegible]	[illegible]	[illegible]	3 03 13.96		1.07	3 03 13.62	1 03 04.57	....		[illegible]	h1 12 52.18	1 03 03.29	e 6 28 36.03
	135	G. C. 121.......		[illegible]	24.0	40.5	58.3	15.5	[illegible]	[illegible]	3 08 58.20		1.10	3 08 57.86	1 22 31.46	1 46 26.40		....	....	....	....
	136	ν Piscium........		24.8	42.0	58.8	16.2	33.3	50.3	07.7	3 20 16.16		1.10	[illegible]	1 33 49.33	1 46 26.49		....	1 33 49.36	....	....
	137	o Piscium........		15.3	32.6	49.8	07.2	24.3	41.5	[illegible]	3 24 07.07		1.10	3 24 06.75	1 37 40.46	1 46 26.18		....	1 37 40.43	1 37 40.57	....
	138	G. C. 181.......		14.3	36.8	00.2	22.8	45.5	08.4	31.2	3 41 22.74		— 1.10	3 41 22.35	1 54 56.37	1 46 25.98		....	....	....	....
Oct. 8	139	ξ Cygni..........	E.	10.2	29.7	49.4	09.3	[illegible]	48.5	08.3	22 54 09.17	+ 1.50	— 0.52	22 54 09.19	21 06 42.57	1 47 26.62	47 26.98	....	....	....	....
	140	ε Pegasi..........		34.8	52.1	09.3	26.6	44.3	01.5	18.5	23 24 26.73	(— 10.81)	1.10	23 24 26.54	21 36 59.98	1 47 26.56	(+ 2.73)	....	....	....	....
	141	G. C. 1993......		[illegible]	59.3	16.6	33.7	50.8	08.4	25.7	23 56 33.81		0.48	23 56 33.47	22 09 06.69	1 47 26.78		....	....	....	....
	142	G. C. 1999......		41.8	58.8	15.6	33.0	50.2	07.3	24.3	0 01 33.00		— 0.12	0 01 32.76	22 14 06.01	1 47 26 75		....	....	....	....
	143	G. C. 2019......		37.3	57.8	17.9	38.4	58.8	18.9	39.8	0 10 38.41		+ 0.44	0 10 37.81	22 23 10.95	1 47 26.86		....	....	....	....
	144	ξ Pegasi..........		44.6	02.4	19.3	36.9	54.3	11.7	29.2	0 21 36.91		1.10	0 21 36.87	22 34 10.08	1 47 26.79		....	....	....	....
	145	α Piscis Australis.		01.8	21.8	41.3	01.5	21.3	40.8	00.6	0 37 01.30		1.10	0 37 00.77	22 49 23.74	1 47 27.03		....	....	....	....
	146	α Pegasi..........		02.6	20.3	37.8	55.3	13.3	30.8	48.5	0 44 55.51		+ 1.10	0 44 55.46	22 57 28.74	1 47 26.72		....	....	....	....
9	147	o Sagittarii........	W	28.3	46.5	05.0	23.4	41.8	00.1	18.6	20 43 23.39	+ 1.59	+ 0.13	20 43 22.83	18 55 53.55	1 47 29.28	47 29.39	....	....	....	....
	148	π Sagittarii........		37.4	55.6	13.6	32.3	50.4	07.8	27.3	20 48 32.19	(— 13.74)	0.13	20 48 31.65	19 01 02.51	1 47 29.14	(2.08)	....	....	....	....
	149	Moon's 1st limb.		21.5	41.0	00.3	19.6	39.4	58.6	17.8	21 22 19.74		0.13	21 22 19.75	19 18 52.07	....		1 13.85	....	19 18 51.49	6 28 38.86
	150	α Aquilæ.........		15.6	32.4	49.3	07.3	24.6	41.8	59.2	21 31 07 17	+ 1.50	0.07	21 31 06.98	19 43 38.00	1 47 28.98	47 29.39	....	....	....	....
	151	b Sagittarii.......		29.3	48.3	07.5	26.8	46.3	05.4	24.7	21 35 26.90	(— 13.74)	+ 0.04	21 35 26.17	19 47 57.04	1 47 29.13	(+ 2.08)	....	....	19 47 57.06	....
	152	c Sagittarii.......		10.3	29.8	49.2	08.4	27.6	47.3	06.6	21 41 08.46			21 41 07.73	19 53 38.59	1 47 29.14		....	....	....	....
	153	α² Capricorni......		32.5	49.8	07.4	24.8	42.6	59.7	17.7	21 57 24.93			21 57 24.44	20 09 55.39	1 47 29.05		....	....	....	....
10i	154	b Sagittarii.......	W.	30.6	......	......	28.4	47.8	07.3	26.3	21 35 26.65	— 1.50	— 0.27	21 35 27.65	19 47 57.02	1 47 30.63	47 31.14	....	....	....	....
	155	c Sagittarii.......		11.5	31.3	50.6	09.8	29.3	48.7	[illegible]	21 41 09.91	(— 13.28)	+ 0 20	21 41 09.00	19 53 38.57	1 47 30.43	(+ 2.53)	....	....	....	....
	156	α² Capricorni......		34.3	51.8	09.0	26.9	44.4	01.8	19.3	21 57 26.79		1.50	21 57 26.20	20 09 55.38	1 47 30.82		....	....	....	....
	157j	Moon's 1st limb.		20.8	40.8	59.3	18.6	38.0	56.9	15.3	22 24 18.53		1.92	22 24 17.85	20 21 37.14	....		1 11.80	....	20 21 36.54	6 28 40.56
12k	158	δ Capricorni......	E.	41.6	59.4	17.3	34.8	52.7	10.6	28.6	23 26 35.00	+ 1.50	+ 1.65	23 26 34.58	21 38 57.47	1 47 37.11	47 37.76	....	....	....	....
	159	μ Capricorni......		03.5	21.2	38.7	56.3	14.0	31.6	49.4	23 32 56.39	(— 12.82)	1.43	23 32 56.01	21 45 18.82	1 47 37.19	(+ 3.07)	....	....	....	....
	160	α Gruis...........		21.8	46.9	12.5	37.7	03.6	28.8	54.8	23 46 38.01	+ 1.01		23 46 36.97	21 58 59.87	1 47 37.10		....	....	....	....
	161	G. C. 1993......		52.3	09.8	26.8	44.0	01.3	18.5	36.2	23 56 44.13		0.68	23 56 43.77	22 09 06.65	1 47 37.12		....	....	....	c6 28 24.11
	162	Moon's 1st limb.		16.8	34.5	52.3	10.6	28.7	46.8	05.1	0 17 10.69		0.68	0 17 10.24	22 16 21.30	....		1 06.84	l22 27.27.06	22 16 20.66	e6 28 24.96
	163	ξ Pegasi..........		55.6	12.8	30.0	47.5	04.8	22.3	39.4	0 21 47.49		0.68	0 21 47.39	22 34 10.05	1 47 37.34		....	....	....	....
	164	τ² Aquarii........		35.6	53.4	10.7	28.3	46.2	03.8	21.3	0 29 28.47		0.68	0 29 28.05	22 41 50.49	1 47 37.56		....	22 41 50.70	....	....
	165	δ Aquarii........		37.3	55.5	13.1	30.9	48.8	06.3	24.4	0 34 30.90		0.68	0 34 30.44	22 46 53.00	1 47 37.44		....	22 46 53.03	....	....
	166	α Piscis Australis.		12.2	32.3	52.0	11.8	31.5	51.3	11.4	0 37 11.79		0.68	0 37 11.12	22 49 33.70	1 47 37.42		....	....	....	....
	167	α Pegasi..........		13.3	30.8	48.4	06.0	23.6	41.3	59.3	0 45 06.10		+ 0.68	0 45 06.07	22 57 28.71	1 47 37.26		....	....	....	....
13	168	τ² Aquarii........	W.	38.8	56.3	13.6	31.5	49.3	07.0	24.4	0 29 31.56	— 1 50	+ 0.27	0 29 31.06	22 41 50.48	1 47 40.58	47 40.59	....	....	....	....
	169	δ Aquarii........		40.5	58.3	16.2	34.3	51.9	09.6	27.3	0 34 34.01	(— 9.28)	0.27	0 34 33.48	22 46 52.99	1 47 40.49	(+ 2.70)	....	22 46 53.12	....	....
	170	α Piscis Australis.		15.4	35.6	54.8	15.1	34.7	54.4	14.3	0 37 14.90		0.27	0 37 14.21	22 49 33.70	1 47 40.51		....	....	....	....
	171	α Pegasi..........		16.3	34.4	51.6	09.6	27.0	44.8	02.3	0 45 09.43		+ 0 27	0 45 09.22	22 57 28.71	1 47 40.51		....	....	....	....

a Fleecy clouds were flying over during the observations. *b* The perfect limb. *c* Deduced from corresponding observations made at Greenwich Observatory.
d 64.77s. = computed time of moon's semi-diam. passed meridian. *e* Deduced from observations made at Philadelphia High School Academy. *f* Clouds have prevented a full set of observations to-night.
g No low star could be taken in consequence of the clouds. *h* 62s.84 = computed time of moon's semi-diam. passing meridian. *i* Clouds prevent further observations. *j* Very cloudy.
k Clouds and rain prevent observations being made bright. *l* 66.98s. = computed time of moon's semi-diam. passing meridian.

Meridian transit observations made at mouth of Rio Grande, &c.—Continued.

Date.	Number for reference.	Name of object.	Illuminated end of axis.	Seconds of transit over the seven wires. I.	II.	III.	IV.	V.	VI.	VII.	Concluded transit over the mean of the seven wires.	Error of— Collima'n, (azimuth.)	Level.	Corrected transit.	Tabular right ascension of known stars and moon's centre.	Chronometer apparently fast of sider'l time.	Adopted chronometer fast at 0h. sider'l time and (gaining rate.)	Sidereal time of semi-diam. passing meridian of station.	App. R. A. of centre deduced from observations made at— High School Observatory, Phila.	Royal Observatory, Gr'nwich.	Long. west of Greenwich deduced from observations of each night.
				s.	s.	s.	s.	s.	s.	s.	h. m. s.	"	"	h. m. s.	h. m. s.	h. m. s.	m s.	m. s.	h. m. s.	h. m. s.	h. m. s.
1853. Oct. 13	172	G. C. 2086	W.	34.2	51.4	08.3	25.7	43.2	00.3	17.3	0 54 25.77	− 1.50	+ 0.27	0 54 25.35	23 06 44.90	1 47 40.45	47 40.59	...	...	...	...
	173	G. C. 2092		09.8	27.3	44.6	02.3	19.3	36.5	54.2	0 59 02.00	(− 9.28)	0.47	0 59 01.55	23 11 21.17	1 47 40.38	(+ 2.70)	...	...	...	a6 28 20.87
	174	Moon's 1st limb.		28.6	46.3	04.4	21.8	39.3	56.7	14.9	1 08 21.71		0.82	1 08 21.28	23 08 16.56	...		1 04.80	b22 18 43.58	23 08 15.90	c6 28 28.00
	175	20 Piscium		15.2	32.4	49.1	06.3	23.6	40.8	57.7	1 28 06.44		0.82	1 28 06.08	23 40 25.49	1 47 40.59		...	23 40 25.43	...	...
	176	27 Piscium		00.8	18.2	35.0	52.3	09.6	26.3	43.5	1 38 52.24		0.82	1 38 51.88	23 51 11.25	1 47 40.63		...	23 51 11.21	...	...
	177	G. C. 2153		40.3	57.8	14.8	32.2	49.3	06.4	28.5	1 45 32.04		+ 0.82	1 45 31.60	23 57 51 21	1 47 40.39		...	...	...	...
17d	178	α Eridani........	E.	32.5	04.8	36.4	09.3	......	......	......	3 20 08.83	+ 1.50	− 0.55	3 20 08.63	1 32 17.71	1 47 50.92	47 50.86	...	...	...	...
	179	α Piscium.........		29.2	46.3	03.4	20.3	37.3	54.3	11.6	3 42 20.34	(− 3.90)	+ 1.38	3 42 20.41	1 54 29.46	1 47 50.95	(+ 2.56)	...	1 54 29.38	...	...
	180	ξ¹ Ceti............		14.7	31.9	49.0	06.6	23.8	41.1	58.3	3 53 06.49		2.33	3 53 06.66	2 05 15.56	1 47 51.10		...	2 05 15.47	...	a6 28 25.89
	181	Moon's 2d limb.		01.6	19.3	36.8	54.8	12.7	30.2	47.9	4 19 54.76		2.33	4 19 54.95	2 18 17.81	...		1 03.10	e2 28 07.46	2 18 17.07	c6 28 34.37
	182	B. A. C. 845		01.8	19.3	36.6	53.6	11.0	28.3	45.0	4 24 53.77		1.88	4 24 53.91	2 37 02.71	1 47 51.20		...	2 37 02.75	2 37 02.71	...
	183f	π Arietis..........		06.0	23.5	41.8	59.7	17.3	34.8	53.3	4 28 59.49		1.50	4 28 59.65	2 41 08.44	1 47 51.21		...	...	...	...
	184	α Ceti.............		38.5	55.4	12.3	29.5	46.8	03.9	20.8	4 42 29.60		1.50	4 42 29.69	2 54 38.56	1 47 51.13		...	...	...	...
	185	G. C. 274........		44.6	04.3	23.8	43.8	03.3	22.8	42.6	4 53 43.60		+ 0.28	4 53 43.47	3 05 52.32	1 47 51.15		...	...	...	...
18	186	B. A. C. 845	W.	04.6	22.2	39.3	56.7	13.9	31.3	48.5	4 24 56.79	− 1.50	+ 0.27	4 24 56.52	2 37 02.72	1 47 53.80	47 53.42	...	...	2 37 02.72	...
	187	π Arietis..........		08.6	26.8	44 3	02.3	20.3	38.1	55.8	4 29 02.31	(− 9.08)	0.44	4 29 02.14	2 41 08.46	1 47 53.68	(+ 2.88)	...	2 41 08.44	...	a6 28 20.6
	188	Moon's 2d limb..		01.3	19.2	36.8	55.3	13.4	31.5	49.3	5 07 55.26		2.06	5 07 55.20	3 05 54.03	...		1 04.06	g3 15 59.50	3 05 53.28	c6 28 24.09
	189	η Tauri...........		46.0	04.4	22.6	41.8	00.5	18.8	37.7	5 26 41.69		2.06	5 26 41.70	3 38 47.99	1 47 53.71		...	...	3 38 48 03	...
	190	32 Tauri...........		12.3	31.3	49.5	07.8	26.3	44.8	03.2	5 36 07.89		1.55	5 36 07.94	3 48 14.10	1 47 53.84		...	3 48 13.97	...	...
	191	γ¹ Eridani.........		14.2	31.8	49.3	06.8	24.0	42.3	59.6	5 39 06.94		1.38	5 39 06.51	3 51 12.71	1 47 53.80		...	...	...	...
	192	G. C. 344.......		02.3	20.4	38.6	57.2	15.8	33.8	52.1	5 43 57.17		1.10	5 43 57.09	3 56 03.35	1 47 53.74		...	...	...	...
	193	G. C. 362......		29.4	47.4	04.5	22.3	40.3	57.8	15.7	5 59 22.49		+ 1.10	5 59 22.34	4 11 28.51	1 47 53.83		...	...	...	...
19	194	η Tauri	E.	49.3	07.8	26.4	45.3	03.7	22.5	41.3	5 26 45.19	+ 1.50	− 0.41	5 26 45.24	3 38 48.01	1 47 57.23	47 56.62	...	3 38 48.16	3 38 48.05	...
	195	32 Tauri		16.0	34.3	52.6	11.4	29.6	48.2	06.5	5 36 11.23	(− 13.24)	+ 0.09	5 36 11.28	3 48 14.13	1 47 57.15	(+ 3.30)	...	3 48 14.05	...	...
	196	γ¹ Eridani.........		17.6	35.1	52.5	10.3	27.7	45.4	03.3	5 39 10.27		0.26	5 39 09.80	3 51 12.73	1 47 57.07		...	...	...	...
	197	G. C. 344.......		05.3	23.8	42.2	00.4	19.0	37.4	55.8	5 44 00.56		0.55	5 44 00.64	3 56 03.38	1 47 57.26		...	...	...	a6 28 24.86
	198	Moon's 2d limb.		34.6	53.2	11.6	30.5	49.3	07.5	26.3	5 57 30.43		0.55	5 57 30.49	3 54 56.86	...		1 05.32	h4 05 23.77	3 54 56.38	c6 28 27 56
	199	G. C. 363.......		18.2	38.5	59.3	20.2	40.4	01.3	22.3	6 00 20.03		0.68	6 00 19.25	4 12 22.01	1 47 57.24		...	...	...	...
	200	G. C. 370		35.5	53.6	12.3	30.8	49.3	07.7	26.4	6 05 30.80		0.91	6 05 30.92	4 17 33.75	1 47 57.17		...	...	...	...
	201	α Tauri		35.6	53.5	11.3	29.0	46.8	04.4	22.3	6 15 28.99		1.37	6 15 29.02	4 27 31.95	1 47 57.07		...	4 27 31.95	...	...
	202	G. C. 400		29.8	48.3	06.8	25.2	43.7	02.3	20.9	6 21 25.29		+ 1.65	6 21 25.47	4 33 28.25	1 47 57.22		...	...	...	...
20	203	θ Tauri..........	W.	26.7	44.5	02.3	20.2	37.6	55.3	13.0	6 08 19.94	− 1.50	+ 0.55	6 08 19.80	4 20 19.05	1 48 00.75	48 00.03	...	...	...	...

	204	α Tauri		39.3	57.6	14.9	31.2	50.6	08.3	26.[illegible]	6 15 32.91	(— 6.43)	1.30	6 15 32.82	4 27 31.97	1 48 00.85	(+ 3.46)	....	....	....	....
	205	G. C. 400		33.3	52.3	10.4	29.3	47.8	06.3	24.8	6 21 29.17		0.13	6 21 29.16	4 33 28.28	1 48 00.88		....	....	....	....
	206	G. C. 405........		56.0	14.3	31.8	50.1	08.0	26.0	44.3	6 40 50.07		2.75	6 30 50.11	4 42 49.32	1 48 00.71		....	....	....	....
	207	Moon's 2d limb.		.....	16.8	31.8	54.3	13.3	32.2	51.3	6 48 54.41		1.65	6 48 54.34	4 45 45.58	....		1 06.59	....	4 45 45.37	6 28 42.03
	208	o Tauri		56.7	15.2	33.4	52.0	10.3	28.6	47.3	7 06 51.93		1.65	7 06 51.81	5 18 51.05	1 48 00.76		....	....	....	....
	209	α Leporis		24.4	42.6	00.3	18.3	36.3	54.2	12.2	7 14 18.33		1.92	7 14 18.01	5 26 16.93	1 48 01.08		....	....	....	....
	210	ξ Tauri		00.3	18.5	36.4	55.3	13.6	31.8	49.9	7 16 55.11		2.04	7 16 55.10	5 28 54.19	1 48 00.91		....	....	....	....
	211	G. C. 493		07.2	25.6	44.4	03.3	22.1	40.5	59.4	7 28 03.21		+ 2.47	7 28 03.27	5 40 02.34	1 48 00.93		....	....	....	....
21	212	o Tauri	E.	......	18.3	36.8	55.3	13.8	32.4	50.6	7 06 55.28	+ 1.50	— 0.55	7 06 55.15	5 18 51.08	....	48 03.55	....	....	....	....
	213	α Leporis........		27.8	46.2	03.6	21.6	39.7	57.8	15.8	7 14 21.79	(— 12.68)	+ 0.18	7 14 21.28	5 26 16.96	1 48 04.32	(+ 3.68)	....	....	....	....
	214	ξ Tauri		......	22.0	40.1	58.3	16.8	35.2	53.5	7 16 58.48		0.50	7 16 58.60	5 28 54.22	1 48 04.38		....	....	....	....
	215	Moon's 2d limb.		00.6	19.7	38.5	57.8	......	36.6	......	7 41 57.94		+ 0.68	7 41 58.10	5 38 19.40	....		1 07.66	....	5 38 19.19	6 28 41.25
22	216	α Columbæ.......	W.	28.5	49.3	09.6	30.3	50.8	11.7	31.8	7 22 30.29	— 1.50	+ 1.23	7 22 29.99	5 34 21.67	1 48 08.32	48 07.40	....	....	....	....
	217	α Orionis.........		31.6	49.3	06.2	23.3	41.0	57.8	15.3	7 35 23.50	(— 3.31)	1.23	7 35 23.41	5 47 15.08	1 48 08.33	(+ 3.75)	....	....	....	....
	218	η Geminorum ...		15.6	34.3	52.3	11.3	29.4	47.8	06.4	7 54 11.01		1.23	7 54 10.98	6 06 02.48	1 48 08.50		....	....	....	....
	219	μ Geminorum		19.3	37.5	56.3	14.7	33.3	52.0	10.2	8 02 14.76		2.10	8 02 14.79	6 14 06.34	1 48 08.45		....	....	....	....
	220	G. C. 587.......		07.2	26.3	44.6	[illegible]	22.8	41.8	00.4	8 23 03.84		2.10	8 23 03.88	6 34 55.49	1 48 08 39		....	....	....	....
	221	Moon's 2d limb.		17.2	36.7	55.5	14.8	34.3	53.9	13.0	8 36 15.06		2.71	8 36 15.15	6 32 15.86	....		1 08.28	....	6 32 15.65	6 28 11.11
	222	ξ Geminorum		38.6	57.2	15.6	33.7	52.3	10.3	28.5	8 43 33 74		+ 3.02	8 43 33.82	6 55 25.38	1 48 08.44		....	....	....	....
Nov. 7	223	ρ Capricorni	E.	41.6	59.5	17.3	35.5	53.6	11.3	......	22 09 35.38	+ 1.50	+ 0.40	22 09 34.92	20 20 29.59	1 49 05.33	49 05.87	....	....	....	....
	224	ψ Capricorni......		34.2	52.8	11.8	30.8	50.0	08.6	27.8	22 26 30.86	(— 13.23)	+ 0.40	22 26 30.22	20 37 24.64	1 49 05.58	(+ 3.57)	....	....	20 37 24.60	....
	225	ξ Cygni		48.6	07.8	27.5	47.3	07.3	26.5	46.3	22 55 47.33		— 0.11	22 55 47.36	21 06 42.01	1 49 05.35		....	....	....	....
	226	Moon's 1st limb.		03.6	22.3	41.0	59.8	18.8	37.5	56.3	23 06 59.90		0.27	23 06 59.31	21 03 15.90	....		1 10.61	....	21 03 14.68	a6 28 36.94
	227	δ Capricorni......		09.8	27.6	45.2	03.3	21.0	38.8	56.8	23 28 03.21		0.27	23 28 02.68	21 38 57.11	1 49 05.57		....	....	21 38 57.21	....
	228	μ Capricorni......		31.7	49.3	06.8	24.5	42.3	59.6	17.5	23 34 24.53		0.27	23 34 24.04	21 45 18.47	1 49 05.57		....	....	21 45 18.52	....
	229	α Gruis		49.8	15.3	40.5	05.6	31.3	56.6	22.0	23 48 05.87		— 0.27	23 48 04.74	21 58 59.34	1 49 05.40		....	....	....	....
8	230	δ Capricorni......	W.	13.2	31.3	48.6	06.8	24.6	42.3	00.3	23 28 06.73	— 1.50	+ 0.27	23 28 06.23	21 38 57.09	1 49 09.14	49 09.37	....	21 38 57.26	21 38 57.19	....
	231	μ Capricorni......		35.2	53.0	10.2	28.0	45.7	03.3	20.8	23 34 28.03	(— 8.81)	+ 0.19	23 34 27.55	21 45 18.46	1 49 09.09	(+ 3.74)	....	21 45 18.70	21 45 18.51	....
	232	α Gruis		52.8	18.8	43.8	09.3	34.5	00.3	24.8	23 48 09.19		....	23 48 08.21	21 58 59.34	1 49 08.87		....	....	....	a6 28 34.05
	233	Moon's 1st limb		59.8	17.8	36.3	54.5	12.8	31.0	48.8	0 02 54.43		....	0 02 53.92	22 00 15.98	....		1 07.75	22 00 26.29	22 00 14.81	j6 28 34.53
	234	σ Aquarii..........		11.3	28.8	46.3	03.5	20.7	38.5	55.8	0 12 03.56		+ 0.11	0 12 03.11	22 22 53.79	1 49 09.32		....	22 22 53.69	22 22 53.84	....
	235	ξ Pegasi...........		27.0	44.6	01.8	19.3	36.7	53.3	11.3	0 23 19.14		0.27	0 23 18.89	22 34 09.76	1 49 09.13		....	....	....	....
	236	δ Aquarii		08.8	26.8	44.3	02.2	20.6	38.0	55.8	0 36 02.36		0.27	0 36 01.86	22 46 52.73	1 49 09.13		....	22 46 52.87	22 46 52.81	....
	237	α Piscis Australis.		43.8	03.8	23.0	43.3	03.0	22.6	42.5	0 38 43.14		0.77	0 38 42.50	22 49 33.39	1 49 09.11		....	....	....	....
	238	α Pegasi...........		44.3	02.3	19.8	37.6	55.4	12.8	30.3	0 46 37.50		+ 2.06	0 46 37.42	22 57 28.46	1 49 08.96		....	....	....	....
9	239	σ Aquarii	E.	14.6	32.3	49.4	06.8	24.3	41.5	59.3	0 12 06.89	+ 1.50	....	0 12 06.86	22 22 53.78	1 49 13.08	49 13.35	....	22 22 53.68	22 22 53.83	....
	240	ξ Pegasi...........		30.8	48 3	05.5	[illegible]	40.3	57.3	14.9	0 23 22.84	(— 3.09)	— 0.20	0 23 22.87	22 34 09.75	1 49 13.12	(+ 4.17)	....	....	....	....
	241	δ Aquarii		12.3	30.3	48.2	05.8	23.8	41.5	59.6	0 36 05.93		— 0.47	0 36 05.86	22 46 52.71	1 49 13.15		....	22 46 52.76	22 46 52.79	....

a Deduced from corresponding observations made at Greenwich Observatory.
c Deduced from corresponding observations made at Philadelphia High School Observatory.
e 63s.05. = computed time of moon's semi-diam. passing meridian.
g 64s.00. = computed time of moon's semi-diam. passing meridian.
i No further observations this morning, in consequence of the thickening clouds.

b 64s.90. = computed time of moon's semi-diam. passing meridian.
d Oct. 16.—Clouds prevent observations being made to-night.
f Not satisfactory, because of clouds.
h 65s.24. = computed time of moon's semi-diam. passing meridian.
j Deduced from corresponding observations made at Radcliffe Observatory

Meridian transit observations made at mouth of Rio Grande, &c.—Continued.

Date.	No. for reference.	Name of object.	Illuminated end of axis.	Seconds of transit over the seven wires. I.	II.	III.	IV.	V.	VI.	VII.	Concluded transit over the mean of the seven wires.	Error of— Collima'n, (azimuth.)	Level.	Corrected transit.	Tabular right ascension of known stars and moon's centre.	Chronometer apparently fast of sider'l time.	Adopted chronometer fast at 0h. sider'l time and (gaining rate.)	Sidereal time of semi-diam. passing meridian of station.	App. R. A. of centre deduced from observations made at— High School Observatory, Phila.	Royal Observatory, Gr'nwich.	Long. west of Greenwich deduced from observations of each night.
				s.	s.	s.	s.	s.	s.	s.	h. m. s.	"	"	h. m. s.	h. m. s.	h. m. s.	m. s.	m. s.	h. m. s.	h. m s.	h. m. s.
1853. Nov. 9	242	α Piscis Australis.	E.	47.3	06.8	26.5	46.6	06.3	26.0	46.3	0 38 46.54	+ 1.50	− 0.52	0 38 46.43	22 49 33.37	1 49 13.06	49 13.35	....	....	....	....
	243	α Pegasi..........		48.5	06.2	23.6	41.3	59.0	16.8	34.4	0 46 41.40	(− 3.09)	0.68	0 46 41.41	22 57 28.45	1 49 12.96	(+ 4.17)	....	....	....	a6 28 32.15
	244	Moon's 1st limb.		54.7	12.3	30.3	48.2	06.3	23.5	41.3	0 54 48.09		0.68	0 54 48.02	22 53 03.22	....		1 05.53	22 53 13.08	22 53 02.20	6 28 30.50
	245	φ Aquarii.........		......	......	......	......	15.3	32.3	49.5	0 55 57.87		0.84	0 55 57.87	23 06 44.69	1 49 13.18		....	23 06 44.49	23 06 44.54	....
	246	ψ^2 Aquarii		42.3	59.4	16.8	34.5	51.8	09.0	26.6	1 00 34.34		− 1.65	1 00 34.23	23 11 20.85	1 49 13.38		....	23 11 21.12	23 11 20.97	....
10	247	ξ Pegasi..........	W.	35.0	52.6	09.8	27.5	44.8	01.8	19.4	0 23 27.27	− 1.50	+ 1 00	0 23 27.12	22 34 09.73	1 49 17.39	49 17.72	....	....	....	....
	248	α Piscis Australis.		51.6	12.2	31.5	51.6	11.3	31.3	50.8	0 38 51.47	(− 6.24)	1.00	0 38 51.01	22 49 33.36	1 49 17.65	(+ 4.15)	....	....	....	....
	249	α Pegasi..........		53.3	10.8	28.3	46.3	03.8	21.4	38.9	0 46 46.11		0.57	0 46 46.03	22 57 28.43	1 49 17.60		....	....	....	....
	250	φ Aquarii.........		10.6	28.3	45.0	02.6	19.8	36.8	53.9	0 56 02.43		0.00	0 56 02.21	23 06 44.68	1 49 17.53		....	23 06 44.49	23 06 44.74	....
	251	ψ^3 Aquarii.........		46.5	03.8	21.4	38.5	56.3	13.3	30.8	1 00 38.66		0.82	1 00 38.41	23 11 20.84	1 49 17.57		....	23 11 21.09	23 11 20.97	....
	b252	27 Piscium.........		37.5	54.8	......	......	46.3	03.3	......	1 40 29.10		0.82	1 40 28.91	23 51 11.10	1 49 17.81		....	23 51 11.29	23 51 11.13	a6 28 26.23
	253	Moon's 1st limb.		47.9	05.8	23.2	40.7	58.3	15.6	33.3	1 43 40.69		1.18	1 43 40.47	23 42 31.72	....		1 03.57	23 42 41.18	23 42 31.11	c6 28 31.07
	b254	33 Piscium.........		17.3	34.5	......	09.0	......	......	......	1 47 08.95		+ 1.65	1 47 08.73	23 57 50.98	1 49 17.75		....	23 57 51.04	23 57 50.99	....
11	255	27 Piscium.........	E.	41.7	59.0	......	32.8	50.6	07.4	24.8	1 40 33.34	+ 1.50	− 0.27	1 40 32.94	23 51 11.09	1 49 21.85	49 21.65	....	23 51 11.28	23 51 11.12	....
	256	33 Piscium.........		21.5	38.8	55.8	13.3	30.3	47.3	04.8	1 47 13.11	(− 16.22)	0.66	1 47 12.59	23 57 50.97	1 49 21.62	(+ 4.20)	....	23 57 51.03	23 57 50.98	....
	257	α Andromedæ		13.6	32.9	52.3	11.7	31.3	50.6	10.0	1 50 11.77		0.82	1 50 11.77	0 00 50.18	1 49 21.59		....	....	....	....
	258	β Ceti..........		43.3	01.3	19.3	37.2	55.4	13.5	31.8	2 25 37.40		0.82	2 25 36.65	0 36 15.03	1 49 21.62		....	....	....	....
	[illegible]	Moon's 1st limb.		45.8	03.0	20.5	37.6	55.3	12.4	29.8	2 30 37.77		1.27	2 30 37.31	0 29 47.74	....		1 02.56	0 29 56.95	0 29 47.14	a6 28 23.32
	260	20 Ceti............		03.3	20.5	37.4	54.8	11.8	28.6	46.2	2 34 54.66		− 1.65	2 34 54.16	0 45 32.32	1 49 21.84		....	0 45 32.36	0 45 32.38	....
12	261	δ Piscium......	W.	41.0	58.3	15.5	32.8	50.2	07.3	24.0	2 30 32.73	− 1.50	− 0.27	2 30 32.38	0 41 06.05	1 49 26.33	49 26.13	....	0 41 06.00	0 41 05.96	....
	262	20 Ceti............		07.8	24.8	41.6	59.3	16.3	33.3	50.2	2 34 59.04	(− 6.69)	1.06	2 34 58.67	0 45 32.31	1 49 26.36	(+ 4.30)	....	0 45 32.37	0 45 32.37	....
	[illegible]	G. C. 66		56.6	14.2	30.9	48.3	05.4	22.8	40.3	2 44 48.36		3.02	2 44 47.92	0 55 21.67	1 49 26.25		....	0 55 21.70	0 55 21.70	....
	264	G. C. 121		07.3	24.3	41.3	58.8	15.8	32.9	50.0	3 11 58.63		2.48	3 11 58.22	1 22 31.85	1 49 26.37		....	1 22 31.83	1 22 31.89	....
	265	Moon's 1st limb.		23.2	10.4	28.0	45.3	03.3	20.3	37.6	3 16 45.44		2.11	3 16 45.05	1 15 57.47	....		1 02.26	....	1 15 56.83	a6 28 34.55
	266	α Eridani.........		07.8	40.6	12.5	45.3	18.8	49.3	21.4	3 21 44.81		1.66	3 21 43.76	1 32 17.16	1 49 26.60		....	....	....	....
	267	ο Piscium		15.5	33.0	50.2	07.6	24.8	41.8	59.3	3 27 07.46		− 1.10	3 27 07.15	1 37 40.93	1 49 26 62		....	1 37 40.84	1 37 41.06	....
13	268	ν Piscium.........	E.	28.9	46.3	03.4	20.3	37.8	54.8	12.2	3 23 20.53	+ 1.50	− 1.10	3 23 20.32	1 33 49.77	1 49 30.55	49 30.25	....	....	1 33 49.80	....
	269	ο Piscium.........		19.6	37.3	54.3	11.5	29.0	46.3	03.6	3 27 11.66	(− 6.20)	2.20	3 27 11.49	1 37 40 93	1 49 30.56	(+ 3.88)	....	1 37 40.84	1 37 41.06	....
	270	Moon's 1st limb.		08.3	25.8	43.6	00.8	18.8	36.4	53.9	4 03 01.09		3.08	4 03 00.87	2 02 01.52	....		1 02.62	....	2 02 00.84	a6 28 35.93
	271	ξ^2 Ceti............		03.2	20.3	37.3	54.8	11.8	29.3	46.6	4 09 54.76		3.85	4 09 54.48	2 20 23.85	1 49 30.63		....	2 20 23.75	2 20 23.80	....
	[illegible]	B. A. C. 845.....		42.3	59.5	16.4	33.8	51.3	08.5	25.8	4 26 33.94		3.85	4 26 33.68	2 37 02.98	1 49 30.70		....	2 37 03.10	2 37 02.95	....

14	273	ξ² Ceti	W.	06.3	23.8	40.9	58.3	15.6	32.8	50.0	4 09 58.54	− 1.50	− 0.82	4 09 58.27	2 20 23.85	1 49 34.42	49 33.89		2 20 23.75	2 20 23.80	
	274	B. A. C. 845		45.8	03.3	20.3	37.5	55.2	12.3	29.6	4 26 37.71	(− 5.71)	1.98	4 26 37.38	2 37 02.98	1 49 34.40	(+ 4.08)		2 37 03.10	2 37 02.95	
	275	G. C. 244		49.6	07.7	25.3	43.3	01.4	19.0	[illegible]	[illegible]		2.25	4 30 42.99	2 41 08.80	1 49 34.19			2 41 08.75	2 41 08.75	
	276	G. C. 254		31.5	50.2	08.2	26.6	44.8	03.3	21.4	4 40 26.57		2.88	4 40 26.23	2 50 51.99	1 49 34.24				2 50 51.96	a6 28 33.60
	d277	Moon's 1st limb		20.3	38.3	56.3	14.3	32.5	50.2	[illegible]	4 50 14.31		2.88	4 50 13.96	2 48 52 10			1 03.50	2 49 01.40	2 48 51.37	c 6 28 30.44
	278	Moon's 2d limb		27.6	45.5	03.4	21.8	39.4	57.3	15.3	4 52 21.47		2.75	4 52 21.11	2 48 52.10			[illegible]			
	279	G. C. 274		28.8	48.3	07.5	27.5	47.2	06.8	26.3	4 55 27.49		2.54	4 55 26.90	3 05 52.63	1 49 34.27					
	280	τ¹ Arietis		27.8	46.0	04.2	22.4	40.8	58.9		5 02 22.54		− 2.06	5 02 22.25	3 12 47 93	1 49 34.32			3 12 47.99	3 12 48.01	
15	281	G. C. 274	E.	33.3	52.8	12.5	32.3	51.8	11.6	31.0	4 55 32.19	+ 1.50	− 1.92	4 55 31.50	3 05 52.63	1 49 38.87	49 38.41				
	282	τ¹ Arietis		32.4	50.7	08 8	26.9	45.3	03.5	22.2	5 02 27.11	(− 11.22)	1.92	5 02 27.01	3 12 47.94	1 49 39.07	(+ 4.76)		3 12 48.00	[illegible]	
	283	η Tauri		31.6	50.3	08.8	27.4	46.3	04.8	23.3	5 28 27.50		1.92	5 28 27.45	3 38 48.33	1 49 39.12			3 38 48.48	3 38 48.46	
	284	Moon's 2d limb		18.3	36.5	55.3	13.3	31.8	50.2	08.6	5 41 13.43		2.80	5 41 13.25	3 37 09.67			1 04.67		3 37 08.86	a6 28 26.41
	285	G. C. 344		48.2	06.4	24.5	43.0	01.6	19.8	38.5	5 45 43.14		3 02	5 45 42.37	3 56 03.88	1 49 39.09					
	286	γ Tauri		15.5	33.3	50.4	08.3	26.3	43.8	01.6	6 01 08.46		3.02	6 01 08.20	4 11 29.14	1 49 39.06				4 11 28.95	
	287	δ² Tauri		26.6	44.4	02.0	19.8	37.8	55.6	13.5	6 05 19.94		− 2.97	6 05 19.71	4 15 40.75	1 49 38.96			4 15 40.70	4 15 40.69	
[illegible]	288	δ² Tauri	W.				25.3	43.3	01.0	18.6	6 05 25.30	− 1.50	+ 0.55	6 05 25.05	4 15 40.77	1 49 44.28	49 43.41		[illegible]	4 15 40.71	
	289	G. C. 370				00.3	18.8	37.3		14.3	6 07 18.90	(− 11.00)	+ 0.55	6 07 18.73	4 17 34.33	1 49 44.40	(+ 5.30)				
[illegible]	290	α Columbæ	E.	17.0	37.8	58.3	18.8	39.5	00.3	21.2	7 24 18.99	+ 1.50	− 2.20	7 24 18.28	5 34 22.34	1 49 55.94	49 54.61				
	291	132 Tauri		02.6	21.3	40.3	58.7	17.6	36.3	55.5	7 29 58.90	(− 10.57)	2.20	7 29 58.94	5 40 02.79	1 49 56.05	(+ 5.33)			5 40 02.82	
	292	[illegible] Tauri		06.8	26.0	45.3	04.3	23.8	42.8	02.6	7 34 04.51		2.20	7 34 04.43	5 44 08.69	1 49 55.74				[illegible]	
	293	G. C. 535		04.2	22.4	40.8	59.3	18.3	36.3	55.3	7 55 59.51		2.20	7 55 59.42	6 06 03.48	1 49 55.94				6 06 03.36	
	294	Moon's 2d limb		38.6	56.3	15.5	34.8	54.4	13.6	33.3	8 18 34.94		3.70	8 18 34.77	6 12 53.80			1 07.95		6 12 53.44	a6 28 28.67
	295	ε Geminorum		55.8	14.8	33.6	52.6	11.5	30.3	49.3	8 24 52.56		3.80	8 24 52.38	6 34 56.36	1 49 56.02				6 34 56.28	
	296	α Canis Majoris		45.8	04.0	21.5	39.4	57.3	15.0	32.6	8 28 39.37		3.85	8 28 38.77	6 38 42.71	1 49 56.06					
	297	ζ Geminorum		27.9	46.3	04.2	22.6	40.8	59.3	17.5	8 45 22.66		− 3.85	8 45 22.44	6 55 26.22	1 49 56.22				6 55 26.25	
f21	298	γ Cancri	W.	05.3	24.3	42.5	01.5	19.6	37.8	56.2	10 25 01.03	− 1.50	− 3.30	10 25 00.63	8 34 48.94	1 50 11.69	50 10.00			8 34 48.86	
	299	Moon's 2d limb		34.4	53.3	12.0	30.8	49.3	08.2	26.6	11 00 30.66	(− 10.57)	3.30	11 00 30.26	8 54 58.53		(+ 4.94)	1 07.00		8 54 58.29	a6 28 29.45
	300	λ Leonis		37.8	56.6	15.3	34.3	52.8	11.5	29.8	11 13 34.01		− 4.67	11 13 33.53	9 33 21.76	1 50 11.77					
22	301	λ [illegible]	E.	42.8	01.6	20.2	38.3	57.3	15.5	34.4	11 13 38.59	+ 1.50	− 2.75	11 13 38.47	9 23 21.80	1 50 16.67	50 14.80				
	302	Moon's 2d limb		34.8	53.2	11.6	29.8	48.3	06.3	24.3	11 52 29.76	(− 10.57)	2.75	11 52 29.56	9 47 13.58		(+ 4.80)	1 06.23		9 47 13.17	a6 28 26.91
	303	γ Leonis		16.3	34.0	52.6	10.8	29.0	47.2	05.5	12 02 10.77		− 4.40	12 02 10.51	10 11 53.58	1 50 16.93				10 11 53.61	

a Deduced from corresponding observations made at Greenwich observatory.
c Deduced from corresponding observations made at Radcliffe observatory.
e Clouds prevent further observations this night.

b Clouds.
d No. 277—moon's 1st limb perfect.
f Clouds prevent more observations this night.

TABLE B.

Results of observations made at mouth of Rio Grande for equatorial intervals of 46-inch transit, by Troughton & Simms—illumination east.

Stars observed.	First wire.	Second wire.	Third wire.	Fifth wire.	Sixth wire.	Seventh wire
	s.	s.	s.	s.	s.	s.
α Herculis	50.96	33.97	17.08	17.08	34.17	51.35
γ Draconis	51.07	33.92	17.11	17.11	34.14	51.38
h^2 Sagittarii	50.99	33.98	16.87	17.19	34.20	51.35
γ Aquilæ	50.92	34.00	17.17	17.22	34.29	51.22
b Sagittarii	51.29	34.04	17.11	17.11	34.13	51.29
β Capricorni	51.18	34.10	17.27	17.08	34.15	51.13
μ Capricorni	51.08	33.92	16.82	17.11	34.02	51.13
α Pegasi	51.23	33.90	17.00	17.24	33.96	51.38
π Capricorni	51.20	34.19	17.05	17.15	33.96	51.15
ξ Cygni	51.02	33.90	....	17.38	34.33	51.46
ψ^3 Aquarii	51.14	33.93	17.06	17.06	34.08	51.14
β Aquilæ	51.11	33.96	17.20	17.30	34.16	51.51
δ Aquilæ	51.19	34.16	16.98	17.13	34.01	51.34
α Aquilæ	....	....	17.22	....	....	....
α^2 Capricorni	51.01	....	17.05	17.24	34.10	51.30
α Cygni	51.26	34.08	16.90	17.23	34.29	51.22
61^1 Cygni	51.12	34.11	17.13	....	34.22	....
α Cephei	51.16	34.10	17.20	17.13	34.17	51.39
β Cephei	51.20	34.24	17.19	17.19	34.25	51.44
t^2 Aquarii	51.15	34.10	17.14	17.34	34.24	51.20
α Piscis Australis	....	33.98	16.99	17.12	34.07	51.45
α Persei	....	34.11	17.27	17.14	34.15	51.38
δ Capricorni	51.21	34.08	17.18	17.18	33.99	51.27
ξ Pegasi	51.15	33.87	....	17.33	34.17	51.49
20 Ceti	51.17	34.13	17.19	17.34	34.13	51.42
Mean	= 51.13	34.03	17.09	17.19	34.14	51.32

Equatorial intervals of 46-inch transit, by Troughton & Simms—illumination east. (C. N. Thom, computer.)

First wire.	Second wire.	Third wire.	Fifth wire.	Sixth wire.	Seventh wire.
51.13s.	34.03s.	17.09s.	17.19s.	34.14s.	51.32s.
1.7086758	1.5318619	1.2327421	1.2352759	1.5332635	1.7102866

Equatorial reduction to middle wire .... = —0s.06

Log .... —0s.06 = —2.7781513

TABLE B—Continued.

Computation of probable error of equatorial interval of each wire from the middle wire of 46-inch transit, by Troughton & Simms—illumination east. (C. N. Thom, computer.)

First wire.			Second wire.			Third wire.			Fifth wire.			Sixth wire.			Seventh wire.		
Each result.	Δ(final result — each result.)	Δ².	Each result.	Δ(final result — each result.)	Δ².	Each result.	Δ(final result — each result.)	Δ².	Each result.	Δ(final result — each result.)	Δ².	Each result.	Δ(final result — each result.)	Δ².	Each result.	Δ(final result — each result.)	Δ².
s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
50.96	0.17	0.029	33.97	0.06	0.004	17.08	0.01	0.000	17.08	0.11	0.012	34.17	0.03	0.001	51.35	0.03	0.001
51.07	0.06	0.004	33.92	0.11	0.012	17.11	0.02	0.000	17.11	0.08	0.006	34.14	0.00	0.000	51.38	0.06	0.004
50.99	0.14	0.020	33.98	0.05	0.002	16 87	0.22	0.048	17.19	0.00	0.000	34.20	0.06	0.004	51.35	0.03	0.001
50.92	0.21	0.044	34.00	0.03	0.001	17.17	0.08	0.006	17.22	0.03	0.001	34.29	0.15	0.022	51.22	0.10	0.010
51.29	0.16	0.026	34.04	0.01	0.000	17.11	0.02	0.000	17.11	0.08	0.006	34.13	0.01	0.000	51.29	0.03	0.001
51.18	0.05	0.002	34.10	0.07	0.005	17.27	0.18	0.032	17.08	0.11	0.012	34.15	0.01	0.000	51.13	0.19	0.036
51.08	0.05	0.002	33.92	0.11	0.012	16.82	0.27	0.073	17.11	0.08	0.006	34.02	0.12	0.014	51.13	0.19	0.036
51.23	0.10	0.010	33.90	0.13	0.017	17.00	0.09	0.008	17.24	0.05	0.002	33.96	0.18	0.032	51.38	0.06	0.004
51.20	0.07	0.005	34.19	0.16	0.026	17.05	0.04	0.001	17.15	0.04	0.001	33.96	0.18	0.032	51.15	0.17	0.029
51.02	0.11	0.012	33.90	0.13	0.017	17.06	0.03	0.001	17.38	0.29	0.055	34.33	0.19	0.036	51.46	0.14	0.020
51.14	0.01	0.000	33.93	0.10	0.010	17.20	0.11	0.012	17.06	0.13	0.017	34.08	0.06	0.004	51.14	0.18	0.032
51.11	0.02	0.000	33.96	0.07	0.005	16.98	0.11	0.012	17.30	0.11	0.012	34.16	0.02	0.000	51.51	0.19	0.036
51.19	0.06	0.004	34.16	0.13	0.017	17.22	0.13	0.017	17.13	0.06	0.004	34.01	0.13	0.017	51.34	0.02	0.000
51.01	0.12	0.014	34.08	0.05	0.002	17.05	0.04	0.001	17.24	0.05	0.002	34.10	0.04	0 001	51.30	0.02	0.000
51.26	0.13	0.017	34.11	0.08	0.006	16.90	0.19	0.036	17.23	0.04	0.001	34.29	0.15	0.022	51.22	0.10	0.010
51.12	0.01	0.000	34.10	0.07	0.005	17.13	0.04	0.001	17.13	0.06	0.004	34.22	0.08	0.006	51.39	0.07	0.005
51.16	0.03	0.001	34.24	0.21	0.044	17.20	0.11	0.012	17.19	0.00	0.000	34.17	0.03	0.001	51.44	0.12	0.014
51.20	0.07	0.005	34.10	0.07	0.005	17.19	0.10	0.010	17.34	0.15	0.022	34.25	0.11	0.012	51.20	0.12	0.014
51.15	0.02	0.000	33.98	0.05	0.002	17.14	0.05	0.002	17.12	0.07	0.005	34.24	0.10	0.010	51.45	0.13	0.017
51.21	0.08	0.006	34.11	0.08	0.006	16.99	0.10	0.010	17.14	0.05	0.002	34.07	0.07	0.005	51.38	0.06	0.004
51.15	0.02	0.000	34.08	0.05	0.002	17.27	0.18	0.032	17.18	0.09	0.008	34.15	0.01	0.000	51.27	0.05	0.002
51.17	0.04	0.001	33.87	0.16	0.026	17.18	0.09	0.008	17.33	0.14	0.020	33.99	0.15	0.022	51.49	0.17	0.029
			34.13	0.10	0.010	17.19	0.10	0.010	17.34	0.15	0.022	34.17	0.03	0.001	51.42	0.10	0.010
												34.13	0.01	0.000			
Eq'l int. = 51.13 s. ± 0.005 s.			Eq'l int. = 34.03 s. ± 0.005 s.			Eq'l int. = 17.09 s. ± 0.006 s.			Eq'l int. = 17.19 s. ± 0.005 s.			Eq'l int. = 34.14 s. ± 0.005 s.			Eq'l int. = 51.32 s. ± 0.005 s.		

TABLE C.

Collimation error of 46-inch transit, determined from observations made at the mouth of the Rio Grande, October 27, 28, and 29, 1853—illuminated end of axis east. (C. N. Thom, computer.)

Date of observation.	Star observed.	Collimation of middle wire, in time.	Date of observation.	Star observed.	Collimation of middle wire, in time.
1853.		s.	[illegible]		s.
October 27	β Cephei..........	0.096	October 28	β Ur. Min........	0.150
27	γ Cephei..........	0.273	29	β Cephei..........	0.165
27	G. C. 177..........	0.050	29	G. C. 1967........	0.081
27	G. C. 210.........	0.158	29	G. C. 907.........	0.086
27	β Ur. Min........	0.163	29	G. C. 958.........	0.357
28	β Cephei..........	0.079	29	γ Cephei..........	0.125
28	G. C. 1967........	0.090	29	G. C. 997.........	0 210
28	γ Cephei..........	0.153	29	G. C. 59..........	0.179
28	G. C. 997..........	0.070	29	G. C. 107.........	0.162
28	G. C. 59..........	0.134	29	G. C. 177.........	0.345
28	G. C. 107..........	0.229	29	G. C. 210.........	0.083
28	G. C. 177..........	0.079	29	β Ur. Min........	0.460
28	G. C. 210..........	0.099			

Sum .... = 25)4.076

Mean collimation of middle wire (in time) .... = + 0s.163

Do............do.........(in arc) .... = + 2″.44

Collimation of mean of wires (in time)........................ = + 0s.10

Do............do........(in arc) .... = + 1″.50

TABLE C—Continued.

Computation of probable error of collimation of middle wire of 46-inch transit, by Troughton & Simms—illumination east. (C. N. Thom, computer.)

Each result.	Δ final result—each result.	Δ²	Each result.	Δ final result—each result.	Δ²
s.	s.	s.	s.	s.	s.
0.096	0.067	0.004	0.150	0.013	0.000
0.273	0.110	0.012	0.165	0.002	0.000
0.050	0.113	0.013	0.081	0.082	0.007
0.158	0.005	0.000	0.086	0.077	0.006
0.163	0.000	0.000	0.357	0.194	0.038
0.079	0.084	0.007	0.125	0.038	0.001
0.090	0.073	0.005	0.210	0.047	0.002
0.153	0.010	0.000	0.179	0.016	0.000
0.070	0.093	0.008	0.162	0.001	0.000
0.134	0.029	0.001	0.345	0.182	0.033
0.229	0.066	0.004	0.083	0.080	0.006
0.079	0.084	0.007	0.460	0.297	0.088
0.099	0.064	0.003			

Final result.. = + 0s.16
Probable error... = ± 0s.01

TABLE D.

Determination of the value of one division of the level used with the 46-inch transit, (by Troughton & Simms,) from observations made at the mouth of the Rio Grande, August 19, 1853. Micrometer attached to zenith. Telescope No. 4. Val. of one rev. = 43″.82. (C. N. Thom, computer.)

Observation.	North end.	Difference.	South end.	Difference.	Mean.	Micrometer reading.	Difference.	Difference in arc.	Val. of one division.
								″	″
1	59	..	19	..	....	16 52.0			
		44	..	44	44.0	......	1 05.5	46.23	1.051
	15	..	63	..	....	15 46.5			
2	51	..	25	..	....	15 59.3			
		36	..	35	35.5	......	0 83.7	36.68	1.033
	15	..	60	..	....	16 43.0			
3	53	..	21	..	....	16 36.5			
		40	..	39	39.5	......	0 98.0	42.94	1.087
	13	..	60	..	....	15 38.5			
4	22	..	49	..	....	12 88.5			
		29	..	30	29.5	......	0 71.5	31.33	1.062
	51	..	19	..	....	13 60.0			
5	51	..	19	..	....	13 60.0			
		39	..	38.5	38.75	......	0 97.0	42.50	1.097
	12	..	57.5	..	....	12 63.0			
6	12	..	57.5	..	....	12 63.0			
		36	..	36.5	36.25	......	0 87.5	38.34	1.058
	48	..	21.0	..	....	13 50.5			

Sum .... = 6).388
Mean value of one division.. = 1″.065

TABLE E.

Table of corrections for errors of collimation, level, and azimuth, at astronomical station near mouth of Rio Grande. (C. N. Thom, computer.)

LATITUDE = 25° 57′.

[NOTE.—In the following tables the decimal fractions are to be multiplied by every *second of arc*, the result being the correction in *time* to be applied to stars having north polar distances corresponding to those in these tables.]

N. P. D.	Z. dist.	COLLIM'N FOR 1″. $\frac{1}{15 \sin N.P.D.}$	LEVEL FOR 1″. $\frac{\cos Z. dist.}{15 \sin N.P.D.}$	AZIMUTH FOR 1″. $\frac{\sin Z. dist.}{15 \sin N.P.D.}$	N. P. D.	Z. dist.	COLLIM'N FOR 1″. $\frac{1}{15 \sin N.P.D.}$	LEVEL FOR 1″. $\frac{\cos Z. dist.}{15 \sin N.P.D.}$	AZIMUTH FOR 1″. $\frac{\sin Z. dist.}{15 \sin N.P.D.}$
°	° ′				°	° ′			
25 sub.-polo ..	89 03	0.158	0.0026	0.158	34 sub.-polo.	30 03	0.119	0.103	0.060
24	88 03	0.164	0.0056	0.164	35	29 03	0.116	0.102	0.056
23	87 03	0.170	0.0088	0.170	36	28 03	0.113	0.100	0.053
22	86 03	0.178	0.0109	0.177	37	27 03	0.111	0.099	0.050
21	85 03	0.186	0.0160	0.185	38	26 03	0.108	0.097	0.047
20	84 03	0.195	0.0202	0.194	39	25 03	0.106	0.096	0.045
19	83 03	0.205	0.0248	0.203	40	24 03	0.103	0.095	0.042
18	82 03	0.216	0.0298	0.214	41	23 03	0.101	0.093	0.040
17	81 03	0.228	0.0354	0.225	42	22 03	0.100	0.092	0.037
16	80 03	0.242	0.0418	0.238	43	21 03	0.098	0.091	0.035
15	79 03	0.258	0.0488	0.253	44	20 03	0.096	0.090	0.034
14	78 03	0.278	0.0571	0.270	45	19 03	0.094	0.089	0.031
13	77 03	0.296	0.0664	0.289	46	18 03	0.093	0.088	0.029
12	76 03	0.321	0.0773	0.311	47	17 03	0.091	0.087	0.027
11	75 03	0.351	0.0901	0.338	48	16 03	0.089	0.086	0.025
10	74 03	0.384	0.105	0.369	49	15 03	0.088	0.085	0.023
9	73 03	0.426	0.124	0.408	50	14 03	0.087	0.084	0.021
8	72 03	0.479	0.147	0.456	51	13 03	0.086	0.083	0.019
7	71 03	0.547	0.178	0.517	52	12 03	0.085	0.083	0.018
6	70 03	0.638	0.217	0.599	53	11 03	0.083	0.082	0.016
5	69 03	0.765	0.273	0.698	54	10 03	0.082	0.081	0.014
5	59 03	0.765	0.383	0.656	55	9 03	0.081	0.080	0.013
6	58 03	0.638	0.337	0.541	56	8 03	0.080	0.080	0.011
7	57 03	0.547	0.297	0.459	57	7 03	0.079	0.079	0.010
8	56 03	0.479	0.267	0.397	58	6 03	0.078	0.078	0.008
9	55 03	0.426	0.244	0.349	59	5 03	0.077	0.077	0.007
10	54 03	0.384	0.225	0.311	60	4 03	0.077	0.077	0.005
11	53 03	0.351	0.210	0.279	61	3 03	0.076	0.076	0.004
12	52 03	0.321	0.197	0.253	62	2 03	0.075	0.075	0.003
13	51 03	0.296	0.186	0.230	63	1 03	0.074	0.075	0.001
14	50 03	0.278	0.177	0.211	64	0 03	0.074	0.074	0.000
15	49 03	0.258	0.169	0.194	65	0 57	0.073	0.073	0.001
16	48 03	0.242	0.162	0.180	66	1 57	0.073	0.073	0.002
17	47 03	0.228	0.155	0.167	67	2 57	0.072	0.072	0.004
18	46 03	0.216	0.150	0.155	68	3 57	0.071	0.072	0.005
19	45 03	0.205	0.145	0.145	69	4 57	0.071	0.071	0.006
20	44 03	0.195	0.140	0.135	70	5 57	0.071	0.070	0.007
21	43 03	0.186	0.136	0.127	71	6 57	0.070	0.070	0.008
22	42 03	0.178	0.132	0.119	72	7 57	0.070	0.069	0.010
23	41 03	0.170	0.129	0.112	73	8 57	0.069	0.069	0.111
24	40 03	0.164	0.125	0.105	74	9 57	0.069	0.068	0.012
25	39 03	0.158	0.122	0.099	75	10 57	0.069	0.068	0.013
26	38 03	0.152	0.120	0.094	76	11 57	0.068	0.067	0.014
27	37 03	0.147	0.117	0.088	77	12 57	0.068	0.067	0.015
28	36 03	0.142	0.115	0.083	78	13 57	0.068	0.066	0.016
29	35 03	0.137	0.113	0.079	79	14 57	0.068	0.066	0.017
30	34 03	0.133	0.110	0.073	80	15 57	0.067	0.065	0.019
31	33 03	0.129	0.108	0.070	81	16 57	0.067	0.064	0.020
32	32 03	0.126	0.106	0.067	82	17 57	0.067	0.064	0.021
33	31 03	0.122	0.105	0.063	83	18 57	0.067	0.063	0.022

TABLE E—Continued.

N. P. D.	Z. dist.	COLLIM'N FOR 1″. $\frac{1}{15 \sin N. P. D.}$	LEVEL FOR 1″. $\frac{\cos Z. dist.}{15 \sin N. P. D.}$	AZIMUTH FOR 1″. $\frac{\sin Z. dist.}{15 \sin N. P. D.}$	N. P. D.	Z. dist.	COLLIM'N FOR 1″. $\frac{1}{15 \sin. N. P. D.}$	LEVEL FOR 1″. $\frac{\cos Z. dist.}{15 \sin N. P. D.}$	AZIMUTH FOR 1″. $\frac{\sin Z. dist.}{15 \sin N. P. D.}$
	° ″				°	° ″			
84 sub.-polo.	19 57	0.067	0.063	0.023	120 sub.-polo	55 57	0.077	0.043	0.064
85	20 57	0.067	0.062	0.024	121	56 57	0.077	0.042	0.065
86	21 57	0.067	0.062	0.025	122	57 57	0.078	0.042	0.067
87	22 57	0.067	0.061	0.026	123	58 57	0.079	0.041	0.068
88	23 57	0.067	0.061	0.027	124	59 57	0.080	0.040	0.070
89	24 57	0.067	0.060	0.028	125	60 57	0.081	0.039	0.071
90	25 57	0.067	0.060	0.029	126	61 57	0.082	0.039	0.073
91	26 57	0.067	0.059	0.030	127	62 57	0.083	0.038	0.074
92	27 57	0.067	0.059	0.031	128	63 57	0.084	0.037	0.076
93	28 57	0.067	0.058	0.032	129	64 57	0.085	0.036	0.078
94	29 57	0.067	0.058	0.033	130	65 57	0.087	0.035	0.079
95	30 57	0.067	0.057	0.034	131	66 57	0.088	0.034	0.081
96	31 57	0.067	0.057	0.035	132	67 57	0.089	0.034	0.083
97	32 57	0.067	0.056	0.036	133	68 57	0.091	0.033	0.085
98	33 57	0.067	0.056	0.038	134	69 57	0.092	0.032	0.087
99	34 57	0.067	0.055	0.039	135	70 57	0.094	0.031	0.089
100	35 57	0.068	0.055	0.040	136	71 57	0.096	0.030	0.091
101	36 57	0.068	0.054	0.041	137	72 57	0.097	0.029	0.093
102	37 57	0.068	0.054	0.042	138	73 57	0.099	0.027	0.096
103	38 57	0.068	0.053	0.043	139	74 57	0.101	0.026	0.097
104	39 57	0.069	0.053	0.044	140	75 57	0.103	0.025	0.101
105	40 57	0.069	0.052	0.045	141	76 57	0.106	0.024	0.103
106	41 57	0.069	0.051	0.046	142	77 57	0.108	0.023	0.106
107	42 57	0.070	0.051	0.047	143	78 57	0.111	0.021	0.109
108	43 57	0.070	0.050	0.049	144	79 57	0.113	0.020	0.112
109	44 57	0.070	0.050	0.050	145	80 57	0.116	0.018	0.115
110	45 57	0.071	0.049	0.051	146	81 57	0.119	0.017	0.118
111	46 57	0.071	0.049	0.052	147	82 57	0.122	0.015	0.121
112	47 57	0.072	0.048	0.053	148	83 57	0.126	0.013	0.125
113	48 57	0.072	0.047	0.055	149	84 57	0.130	0.011	0.129
114	49 57	0.073	0.047	0.056	150	85 57	0.133	0.009	0.133
115	50 57	0.073	0.046	0.057	151	86 57	0.137	0.007	0.137
116	51 57	0.074	0.046	0.058	152	87 57	0.142	0.005	0.142
117	52 57	0.074	0.045	0.060	153	88 57	0.147	0.003	0.147
118	53 57	0.075	0.044	0.061	154	89 57	0.152	0.000	0.152
119	54 57	0.076	0.044	0.062					

TABLE F.

Right ascensions of moon's centre used in computing the longitude of astronomical station near mouth of the Rio Grande, deduced from corresponding moon culminations, observed at Greenwich, Philadelphia High School, and Radcliffe observatories, 1853. (C. N. Thom, computer.)

Date.	Right ascension of moon's centre.		Difference observed: — N. A.	Right ascension of moon's centre observed at Philadel. High School observatory.	Date.	Right ascension of moon's centre.		Difference observed: — N. A.	Right ascension of moon's centre observed at Philadel. High School observatory.
	Greenwich observations.	Nautical Almanac.				Greenwich observations.	Nautical Almanac.		
1853.	h. m. s.	h. m. s.	s.	h. m. s.	1853.	h. m. s.	h. m. s.	s.	h. m. s.
August 12	15 44 14.00	15 44 14.73	— 0.73	....	Oct. 13	23 08 15.62	23 08 16.56	— 0.94	22 18 43.58
13	16 45 08 12	16 45 08.76	0.64	....	14	23 57 27.51	23 57 28.53	1.02	....
14	17 49 14.20	17 49 15.01	0.81	....	15	0 44 53.86	0 44 54.80	0.94	....
15	18 54 04.71	18 54 05.69	0.98	....	16	1 31 32.27	1 31 33.36	1.09	....
16	20 00 25.36	20 00 26.51	1.15	....	17	2 18 16.89	2 18 17.81	0.92	2 28 07.46
17	21 03 07.50	21 03 08.82	1.32	....	18	3 05 53.28	3 05 54.03	0.75	3 15 59.50
18	22 01 55.78	22 01 57.03	1.25	....	19	3 54 56.38	3 54 56.86	0.48	4 05 23.77
19	22 56 38.39	22 56 39.41	1.02	23 07 34.76	20	4 45 45.37	4 45 45.58	0.21	....
20	23 47 49.06	23 47 50.04	0.98	....	21	5 58 19.33	5 58 19.40	— 0.07	....
21	0 36 24.88	0 36 25.73	0.85	0 46 19.72	22	6 32 15.98	6 32 15.86	+ 0.12	....
22	1 23 29.32	1 23 30.03	0.71	....	23	7 26 55.45	7 26 55.23	+ 0.22	....
23	2 10 04.52	2 10 05.09	0.57	....	Nov. 7	21 03 14.68	21 03 15.90	— 1.22	....
24	2 57 07.07	2 57 07.66	0.59	....	8	22 00 14.81	22 00 15.98	1.17	*22 00 26.29
Sept. 11	18 33 26.68	18 33 26.79	0.11	....	9	22 53 02.20	22 53 03.22	1.02	*22 53 13.08
12	19 37 45.20	19 37 45.84	0.64	....	10	23 42 31.11	23 42 31.72	0.61	*23 42 41.18
13	20 40 03.21	20 40 04.07	0.86	20 52 39.82	11	0 29 47.14	0 29 47.74	0.60	....
14	21 39 01.98	21 39 03.06	1.08	....	12	1 15 56.83	1 15 57.47	0.64	....
15	22 34 17.31	22 34 18.61	1.30	....	13	2 02 00.84	2 02 01.52	0.68	....
16	23 26 09.87	23 26 11.40	1.53	23 36 38.50	14	2 48 51.37	2 48 52.10	0.73	*2 49 01.40
17	0 15 26.56	0 15 27.89	1.33	....	15	3 37 08.86	3 37 09.67	0.81	....
18	1 03 03.29	1 03 04.57	1.28	1 12 52.18	16	4 27 17.41	4 27 18.31	0.90	....
19	1 49 57.56	1 49 58.79	1.23	....	17	5 19 19.95	5 19 20.47	0.52	....
20	2 37 02.74	2 37 03.92	1.18	....	18	6 12 53.44	6 12 53.80	0.36	....
October 9	19 18 51.49	19 18 52.07	0.58	....	19	7 07 14.64	7 07 14.86	0.22	....
10	20 21 36.47	20 21 37.14	0.67	....	20	8 01 31.27	8 01 31.30	0.03	....
11	21 20 54.49	21 20 55.25	0.76	....	21	8 54 58.29	8 54 58.53	0.24	....
12	22 16 20.45	22 16 21.30	— 0.85	22 27 27.06	22	9 47 13.17	9 47 13.58	— 0.41	....

* Radcliffe observatory.

TABLE. G.

Tabulation of results for longitude of astronomical station near mouth of Rio Grande, derived from observations made with 46-inch transit (by Troughton & Simms) and with sidereal chronometer No. 2440, (Parkinson & Frodsham:) By G. C. Gardner and J. H. Clark, under the direction of Major W. H. Emory, Chief Astronomer and Surveyor of United States and Mexican boundary survey.

Date of observation.	Moon's limb observed.	Longitude west of Greenwich, deduced from corresponding observations made at— Greenwich Observatory.	Radcliffe Observatory.	Phila. High School Observatory.	Adopted values of the observations for each night.	Date of observation.	Moon's limb observed.	Longitude west of Greenwich, deduced from corresponding observations made at— Greenwich Observatory.	Radcliffe Observatory.	Phila. High School Observatory.	Adopted values of the observations for each night.
1853.		6*h*. 28*m*.	6*h*. 28*m*.	6*h*. 28*m*.		1853.		6*h*. 28*m*.	6*h*. 28*m*.	6*h*. 28*m*.	
		s.	*s*.	*s*.	*s*.			*s*.	*s*.	*s*.	*s*.
Aug. 12	1st........	35.04	....	....	35.04	Oct. 10	1st.......	40.56	....	....	40.56
13		40.00	....	....	40.00	12		24.11	....	24.96	74.03
15		35.91	....	....	35.91	13		20.87	....	28.00	76.87
16		39.85	....	....	39.85	17	2d.......	25.89	....	34.37	94.63
17		29.28	....	....	29.28	18		20.69	....	24.09	68.87
18	2d........	20.69	....	....	20.69	19		24.86	....	27.56	79.98
19		22.33	....	33.62	89.57	20		42.03	....	....	42.03
20		14.71	....	....	14.71	21		41.25	....	....	41.25
21		27.27	....	35.90	99.07	Nov. 7	1st.......	36.94	....	....	36.94
22		27.22	....	....	27.22	8		34.05	34.53	....	68.58
23		33.54	....	....	33.54	9		32.15	30.50	....	62.65
24		32.10	....	....	32.10	10		26.23	31.07	....	57.30
Sept. 12	1st........	30.23	....	....	30.23	11		23.32	....	....	23.32
13		30.48	....	30.60	91.68	12		34.55	....	....	34.55
14		37.08	....	....	37.08	13		35.93	....	....	35.93
15		37.19	....	....	37.19	14	1st & 2d.	33.60	30.44	....	64.04
16		30.72	....	23.86	78.44	15	2d.......	28.41	....	....	28.41
17	2d........	24.60	....	....	24.60	18		28.67	....	....	28.67
18		29.69	....	36.03	101.75	21		29.45	....	....	29.45
Oct. 9	1st........	38.86	....	....	38.86	22		26.91	....	....	26.91

$$\frac{\text{Sum of "Adopted values of the observations for each night,"}}{\text{Number of observations giving to each its value*..............}} = \frac{1951.78}{64} = 30.48$$

		h. m. s.
Longitude of astronomical station near mouth of Rio Grande, west of Greenwich Observatory....................................	=	6 28 30.48
Probable error..	=	± 0.56

NOTE.—Radcliffe Observatory is 5*m*. 02*s*.60 west of Greenwich, (Rad. Observations, vol. XIV, page IX;) High School Observatory, Philadelphia, is 5*h*. 00*m*. 37*s*.56 west of Greenwich Observatory. In reducing the results from the Radcliffe and High School observations to Greenwich Observatory, the above differences of longitudes have been applied.

* In the column, "Adopted values of the observations for each night," the results have been obtained by giving double weight to the High School observations, on account of its relative distance from mouth of Rio Grande, and equal weight to Radcliffe and Greenwich observations.

Computation of probable error of the final result for longitude of astronomical station near mouth of the Rio Grande.

1. RESULTS FROM GREENWICH OBSERVATIONS.

(Final longitude = 6*h*. 28*m*. 30*s*.48.)

Date.	Each result.	Δ (final result — each result.)	Δ²	Date.	Each result.	Δ (final result — each result.)	Δ
1853.	*s.*	*s.*	*s.*	1853.	*s.*	*s.*	*s.*
Aug. 12	35.04	4.56	20.79	Oct. 10	40.56	10.08	101.61
13	40.00	9.52	90.63	12	24.11	6.37	40.57
15	35.91	5.43	29.48	13	20.87	9.61	92.35
16	39.85	9.37	87.73	17	25.89	4.59	21.07
17	29.28	1.20	1.44	18	20.69	9.79	95.84
18	20.69	9.79	95.84	19	24.86	5.62	31.58
19	22.33	8.15	66.42	20	42.03	11.55	133.40
20	14.71	15.77	248.69	21	41.25	10.77	116.00
21	27.27	3.21	10.30	Nov. 7	36.94	6.46	41.73
22	27.22	3.26	10.63	8	34.05	3.57	12.74
23	33.54	3.06	9.36	9	32.15	1.67	2.79
24	32.10	1.62	2.62	10	26.23	4.25	18.06
Sept. 12	30.23	0.25	0.06	11	23.32	7.16	51.26
13	30.48	0.00	0.00	12	34.55	4.07	16.56
14	37.08	6.60	43.56	13	35.93	5.45	29.80
15	37.19	6.71	46.02	14	33.60	3.12	9.73
16	30.72	0.24	0.06	15	28.41	2.07	4.28
17	24.60	5.88	34.57	18	28.67	1.81	3.28
18	29.69	0.79	0.62	21	29.45	1.03	1.06
Oct. 9	38.86	8.38	70.22	22	26.91	3.57	12.74

2. RESULTS FROM PHILADELPAIA HIGH SCHOOL OBSERVATIONS.

(Final longitude = 6*h*. 28*m*. 39*s*.48.)

Date.	Each result.	Δ (final result — each result.)	Δ²	Date.	Each result.	Δ (final result — each result.)	Δ²
1853.	*s.*	*s.*	*s.*	1853.	*s.*	*s.*	*s.*
Aug. 19	33.62	3.14	9.86	Oct. 12	24.96	5.52	30.47
21	35.90	5.42	29.37	13	28.00	2.48	6.04
Sept. 13	30.60	0.12	0.01	17	34.37	3.89	15.13
16	23.86	6.62	43.82	18	24.09	6.39	40.8
18	36.03	5.55	30.80	19	27.56	2.92	8.53

3. RESULTS FROM RADCLIFFE OBSERVATIONS.

(Final longitude = 6*h*. 28*m*. 30*s*.48.)

Date.	Each result.	Δ (final result — each result.)	Δ²	Date.	Each result.	Δ (final result — each result.)	Δ
1853.	*s.*	*s.*	*s.*	1853.	*s.*	*s.*	*s.*
Nov. 8	34.53	4.05	16.40	Nov. 10	31.07	0.59	0.35
9	30.50	0.02	0.00	14	30.44	0.04	0.00

Final longitude .... = 6*h*. 28*m*. 30*s*.48
Probable error .... = ± 0*s*.56

TABLE H.

Tabulation of results for longitude of astronomical station near mouth of Rio Grande, derived from observations made with 46-inch transit, (by Troughton & Simms,) and with sidereal chronometer No. 2440, (by Parkinson & Frodsham) by G. C. Gardner and J. H. Clark, under the direction of Major W. H. Emory, Chief Astronomer and Surveyor of United States and Mexican boundary survey.

MOON'S FIRST LIMB.

Date of observation.	Longitude west of Greenwich, deduced from corresponding observations made at— Greenwich Observatory.	Radcliffe Observatory.	Philadelphia High School Observatory.	Adopted values of the observations for each night.
1853.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*s.*
August 12	6 28 35.04	....	....	35.04
13	6 28 40.00	....	....	40.00
15	6 28 35.91	....	....	35.91
16	6 28 39.85	....	....	39.85
17	6 28 29.28	....	....	29.28
Sept. 12	6 28 30.23	....	....	30.23
13	6 28 30.48	....	6 28 30.60	91.68
14	6 28 37.08	....	....	37.08
15	6 28 37.19	....	....	37.19
16	6 28 30.72	....	6 28 23.86	78.44
October 9	6 28 38.86	....	....	38.86
10	6 28 40.56	....	....	40.56
12	6 28 24.11	....	6 28 24.96	74.03
13	6 28 20.87	....	6 28 28.00	76.87
Nov. 7	6 28 36.94	....	....	36.94
8	6 28 34.05	6 28 34.53	....	68.58
9	6 28 32.15	6 28 30.50	....	62.65
10	6 28 26.23	6 28 31.07	....	57.30
11	6 28 23.32	....	....	23.32
12	6 28 34 55	....	....	34.55
13	6 28 35.93	....	....	35.93
14	6 28 33.60	6 28 30.44	....	64.04

$$\frac{\text{Sum of adopted values of the observations for each night,}}{\text{No. of observations giving to each its value*} \ldots\ldots\ldots\ldots} = \frac{1068.33}{34} = 31.42$$

MOON'S SECOND LIMB.

Date of observation.	Longitude west of Greenwich, deduced from corresponding observations made at— Greenwich Observatory.	Radcliffe Observatory.	Philadelphia High School Observatory.	Adopted values of the observations for each night.
1853.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*s.*
Aug. 18	6 28 20.69	....	....	20.69
19	6 28 22.33	....	6 28 33.62	89.57
20	6 28 14.71	....	....	14.71
21	6 28 27.27	....	6 28 35.90	99.07
22	6 28 27.22	....	....	27.22
23	6 28 33.54	....	....	33.54
24	6 28 32.10	....	....	32.10
Sept. 17	6 28 24.60	....	....	24.60
18	6 28 29.69	....	6 28 36.03	101.75
Oct. 17	6 28 25.89	....	6 28 34.37	94.63
18	6 28 20.69	....	6 28 24.09	68.87
19	6 28 24.86	....	6 28 27.56	79.98
20	6 28 42.03	....	....	42.03
21	6 28 41.25	....	....	41.25
Nov. 14	6 28 33.60	6 28 30.44	....	64.04
15	6 28 28.41	....	....	28.41
18	6 28 28.67	....	....	28.67
21	6 28 29.45	....	....	29.45
22	6 28 26.91	....	....	26.91

$$\frac{\text{Sum of adopted values of the observations for each night,}}{\text{No. of observations giving to each its value*} \ldots\ldots\ldots\ldots} = \frac{947.49}{32} = 29.61$$

	h. m. s.
Resulting longitudes from observations on moon's 1st limb...	= 6 28 31.42
Do..............do..............do.......2d limb...	= 6 28 29.61
Mean longitude..	= 6 28 30.52

Longitude of astronomical station near mouth of Rio Grande, west of Greenwich Observatory........................ = 6*h.* 28*m.* 30*s*.52

NOTE.—Radcliffe Observatory is 5*m.* 02*s*.60 west of Greenwich, (Rad. Observations, vol. XIV, page IX.) High School Observatory, Philadelphia, is 5*h.* 00*m.* 37*s*.56 west of Greenwich Observatory. In reducing the results from the Radcliffe and High School observations to Greenwich observations, the above differences of longitudes have been applied.

* In the column "Adopted values of the observations for each night," the results have been obtained by giving double weight to the High School observations, on account of its relative distance from the mouth of the Rio Grande, and equal weight to Radcliffe and Greenwich observations.

TABLE I.

Tabulation of results for longitude of astronomical station near mouth of Rio Grande, derived from observations made with 46-inch transit, (by Troughton & Simms,) and with sidereal chronometer No. 2440, (by Parkinson & Frodsham:) By G. C. Gardner and J. H. Clark, under the direction of Major W. H. Emory, Chief Astronomer and Surveyor of United States and Mexican boundary survey. (C. N. Thom, computer.)

Date of observation.	Moon's limb observed.	Longitude west of Greenwich, deduced from corresponding observations made at— Greenwich Observatory.	[redacted] Observatory.	Phila. High School Observatory.	Adopted values of the observations for each night.	Date of observation.	Moon's limb observed.	Longitude west of Greenwich, deduced from corresponding observations made at— Greenwich Observatory.	Radcliffe Observatory.	Phila. High School Observatory.	Adopted values of the observations for each night.
1853.		*h. m. s.*	*h. m. s.*	*h. m. s.*	*s.*	1853.		*h. m. s.*	*h. m. s.*	*h. m. s.*	*s.*
Aug. 13	1st........	6 28 40.00	6 28 00.00	....	40.00	Oct. [redacted]	1st......	....	....	6 28 28.00	56.00
17		6 28 29.28	....	....	29.28	17	2d.......	....	....	6 28 34.37	68.74
18	2d.... ...	6 28 20.69	....	....	20.69	18		6 28 20.69	....	6 28 24.09	68.87
19		....	....	6 28 33.62	67.24	19		....	....	6 28 27.56	55.12
21		....	....	6 28 35.90	71.80	20		[redacted]	....	....	[redacted]
23		6 28 33.54	....	....	33.54	Nov. 8	1st......	....	6 28 34.53	....	34.53
24		6 28 32.10	....	....	32.10	9		6 28 32.15	6 28 30.50	....	62.65
Sept. 13	1st........	6 28 30.48	....	6 28 30.60	91.68	10		6 28 26.23	6 28 31.07	....	57.30
16		6 28 30.72	....	6 28 23.86	78.44	11		[redacted]	....	....	[redacted]
17	2d........	6 28 24.60	....	....	24.60	13		6 28 35.93	....	....	35.93
18		6 28 29.69	....	6 28 36.03	101.75	14	1st & 2d.	6 28 33.60	6 28 30.44	....	64.04
Oct. 9	1st........	6 28 38.86	....	....	[redacted]	18	2d.......	6 28 28.67	....	....	28.67
12		....	....	6 28 24.96	[redacted]	21		6 28 29.45	....	....	29.45

$$\frac{\text{Sum of "Adopted values of the observations for each night,"}}{\text{Number of observations giving to each its value*}..........} = \frac{1306.55}{\quad} = \text{[redacted]}$$

Longitude of astronomical station near mouth of Rio Grande, west of Greenwich Observatory.................................... 6*h*. 28*m*. 30*s*.38

NOTE.—Radcliffe Observatory is 5*m*. 02*s*.60 west of Greenwich, (Rad. Observations, vol. XIV, page IX;) High School Observatory, Philadelphia, is 5*h*. 00*m*. 37*s*.56 west of Greenwich Observatory. In reducing the results from the Radcliffe and High School observations to Greenwich Observatory, the above differences of longitudes have been applied.

* In the column, "Adopted values of the observations for each night," the results have been obtained by giving double weight to the High School observations, on account of its relative distance from the mouth of Rio Grande, and equal weight to Radcliffe and Greenwich observations.

TABLE K.

Tabulation of results for longitude of astronomical station near mouth of Rio Grande, derived from observations made with 46-inch transit, (by Troughton & Simms,) and with sidereal chronometer No. 2440, (by Parkinson & Frodsham:) By G. C. Gardner and J. H. Clark, under the direction of Major W. H. Emory, Chief Astronomer and Surveyor of the United States and Mexican boundary survey. (C. N. Thom, computer.)

MOON'S FIRST LIMB.

Date of observation.	Longitude west of Greenwich, deduced from corresponding observations made at— Greenwich Observatory.	Radcliffe Observatory.	Philadelphia High School Observatory.	Adopted values of the observations for each night.
1853.	h. m. s.	h. m. s.	h. m. s.	s.
August 13	6 28 40.00	6 28 00.00	6 28 00.00	40.00
17	6 28 29.28	....	....	29.28
Sept. 13	6 28 30.48	....	6 28 30.60	91.68
16	6 28 30.72	....	6 28 23.86	78.44
October 9	6 28 38.86	....	....	38.86
12	....	....	6 28 24.96	49.92
13	....	....	6 28 28.00	56.00
Nov. 8	....	6 28 34.53	....	34.53
9	6 28 32.15	6 28 30.50	....	62.65
10	6 28 26.23	6 28 31.07	....	57.30
11	6 28 23.32	....	....	23.32
13	6 28 35.93	....	....	35.93
14	6 28 33.60	6 28 30.44	....	64.04

Sum of adopted values of the observations for each night, / Number of observations giving to each its value* ...... $= \frac{661.95}{22} = 30.09$

MOON'S SECOND LIMB.

Date of observation.	Longitude west of Greenwich, deduced from corresponding observations made at— Greenwich Observatory.	Radcliffe Observatory.	Philadelphia High School Observatory.	Adopted values of the observations for each night.
1853.	h. m. s.	h. m. s.	h. m. s.	s.
Aug. 18	6 28 20.69	6 28 00.00	6 28 00.00	20.69
19	....	....	6 28 33.62	67.24
21	....	....	6 28 35.90	71.80
23	6 28 33.54	....	....	33.54
24	6 28 32.10	....	....	32.10
Sept. 17	6 28 24.60	....	....	24.60
18	6 28 29.69	....	6 28 36.03	101.75
Oct. 17	....	....	6 28 34.37	68.74
18	6 28 20.69	....	6 28 24.09	68.87
19	....	....	6 28 27.56	55.12
20	6 28 42.03	....	....	42.03
Nov. 14	6 28 33.60	6 28 30.44	....	64.04
18	6 28 28.67	....	....	28.67
21	6 28 29.45	....	....	29.45

Sum of adopted values of the observations for each night, / Number of observations giving to each its value*...... $= \frac{708.64}{23} = 30.81$

	h. m. s.
Mean longitude from observations on moon's 1st limb.....	=6 28 30.09
Do....... ....do................2d limb.....	=6 28 30.81
Mean longitude from observations on moon's 1st and 2d limbs	=6 28 30.45

Longitude of astronomical station near the mouth of the Rio Grande west of Greenwich Observatory.............................. h. m. s. =6 28 30.45

NOTE.—Radcliffe Observatory is 5*m.* 02.60*s.* west of Greenwich, (Radcliffe Observations, vol. XIV, page IX.) High School Observatory, Philadelphia, is 5*h.* 00*m.* 37.56*s.* west of Greenwich Observatory. In reducing the results from the Radcliffe and High School observations to Greenwich observations, the above differences of longitudes have been applied.

* In the column "Adopted values of the observations for each night," the results have been obtained by giving double weight to the High School observations on account of its relative distance from the mouth of the Rio Grande, and equal weight to the Radcliffe and Greenwich observations.

TABLE VIII.

Tabulation of results for the latitude of astronomical station at Frontera, Texas, derived from observations made with the zenith telescope No. 4, on twenty-four pairs of stars: By Major W. H. Emory, Chief Astronomer and Surveyor of United States and Mexican boundary survey.

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.
	B. A. C. 2194 S. 2270 N.	B. A. C. 2444 S. 2341 N.	B. A. C. 2469 S. 2504 N.	B. A. C. 2472 S. 2504 N.	B. A. C. 2605 S. 2691 N.	B. A. C. 2788 S. 2798 N.	B. A. C. 2818 S. 2855 N.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1852, March 23	....	....	....	31 48 45.44	31 48 39.20	31 48 47.48	31 48 45.62
24	....	....	31 48 41.45	31 48 51.55	31 48 43.67	31 48 48.23	31 48 43.56
25	....	31 48 44.19	31 48 40.03	....	31 48 37.33	31 48 49 27	31 48 44.01
26	....	....	31 48 38.80	31 48 47.83	....	31 48 49 01	31 48 44.01
27	31 48 42.63	31 48 46.35	31 48 41.18	31 48 50.31	31 48 38.79	31 48 49.33	31 48 44 20
28	....	....	31 48 43.93	31 48 47.86	31 48 38.77	31 48 49.76	31 48 43.12
30	....	31 48 44.44	....	....	....	31 48 48 56	31 48 45.23
Latitude by a mean of each pair.	31 48 42.63	31 48 44.99	31 48 41.08	31 48 48.60	31 48 45.55	31 48 48.81	31 48 44.25
Corrections for declination	0.00	0.00	+ 1.20	0.00	+ 0.69	— 3.28	— 1.00
Corrected latitude	31 48 42.63	31 48 44.99	31 48 42.28	31 48 48.60	31 48 46.24	31 48 45.53	31 48 43.25

TABLE VIII—Continued.

Date.	8th pair.	9th pair.	10th pair.	11th pair.	12th pair.	13th pair.	14th pair.
	B. A. C. 2952 S. 2912 N.	B. A. C. 3109 S. 3033 N.	B. A. C. 3181 S. 3131 N.	B. A. C. 3201 S. 3252 N.	B. A. C. 3201 S. 3261 N.	B. A. C. 3355 S. 3399 N.	B. A. C. 3409 S. 3427 N.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1852, March 23	31 48 50.75	31 48 44.97	31 48 34.71	31 48 45 88	31 48 49.25	31 48 46.75	....
24	31 48 49.85	....	....	....	....	....	....
25	31 48 48.87	31 48 42.01	31 48 40.26	31 48 43.12	31 48 42.88	31 48 48.25	31 48 48.33
26	31 48 48.93	31 48 46.18	31 48 41.27	31 48 46.26	31 48 44.41	31 48 47.64	31 48 48.20
27	31 48 50.09	31 48 43.94	31 48 42.01	31 48 46.81	31 48 44.94	31 48 50.31	....
28	31 48 49.93	31 48 44.70	31 48 42.64	....	....	....	....
30	31 48 48.48	31 48 44.45	31 48 41.37	31 48 46.14	31 48 47.21	31 48 47.19	31 48 49.68
Latitude by a mean of each pair.	31 48 49.56	31 48 44.37	31 48 40.38	31 48 45.64	31 48 45.74	31 48 48.03	31 48 48.74
Corrections for declination	— 3.11	+ 1.27	+ 1.56	— 1.86	— 2.86	— 3.91	— 1.21
Corrected latitude	31 48 46.45	31 48 45.64	31 48 41.94	31 48 43.78	31 48 42.88	31 48 44.12	31 48 47.53

TABLE VIII—Continued.

Date.	15th pair.	16th pair.	17th pair.	18th pair.	19th pair.	20th pair.	21st pair.	22d pair.
	B. A. C. 3671 S. 3584 N.	B. A. C. 3710 S. 3736 N.	B. A. C. 3842 S. 3781 N.	B. A. C. 3915 S. 3952 N.	B. A. C. 3990 S. 3973 N.	B. A. C. 4014 S. 4026 N.	B. A. C. 4014 S. 4028 N.	B. A. C. 4066 S. 4126 N.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1852, March 23	31 48 42.88	....	31 48 45.40	31 48 45.28	31 48 45.81	31 48 45.73	31 48 43.36	....
24	....	....	....	....	....	....	....	....
25	31 48 43.03	31 48 39.15	31 48 42.27	31 48 45.28	31 48 45.39	31 48 47.69	31 48 48.38	....
26	31 48 43.78	31 48 41.70	31 48 43.73	31 48 44.49	31 48 44.88	31 48 45.92	31 48 45.82	....
27	31 48 44.87	31 48 40.77	31 48 45.56	31 48 46.58	31 48 45.30	31 48 48.59	31 48 48.74	....
28	....	....	....	....	....	....	....	....
30	31 48 44.58	31 48 43.00	31 48 42.26	....	31 48 44.99	31 48 47.37	31 48 48.07	31 48 50.56
Latitude by a mean of each pair	31 48 43.83	31 48 41.15	31 48 43.84	31 48 45.41	31 48 45.27	31 48 47.06	31 48 46.87	31 48 50.56
Corrections for declination	— 0.12	+ 2.69	— 0.33	0.00	— 1.61	— 2.22	— 2.95	— 1.25
Corrected latitude	31 48 43.71	31 48 43.84	31 48 43.51	31 48 45.41	31 48 43.66	31 48 44.84	31 48 43.92	31 48 49.31

TABLE VIII—Continued.

Date.	23d pair. B. A. C. 4141 S. 4188 N.	24th pair. B. A. C. 4212 S. 4258 N.	Results for latitude by a mean of each night, (declin's corrected.)	1st result. Lat. by a mean of all the pairs, (declin's corrected.)	2d result. Lat. by a mean of all the observations, (declinations corrected.)	3d result. Lat. by a mean of results for each night, (declinations corrected.)	Final result. Mean of 1st, 2d, and 3d results.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1852, March 23	....	....	31 48 43.69				
24	....	....	31 48 45.47				
25	....	....	31 48 43.31				
26	....	....	31 48 44.24				
27	....	....	31 48 44.78				
28	....	....	31 48 44.76				
30	31 48 44.50	31 48 40.80	31 48 44.67				
Latitude by a mean of each pair.	31 48 44.50	31 48 40.80					
Corrections for declination	+ 1.70	— 1.86					
Corrected latitude	31 48 46.20	31 48 38.94		31 48 44.60	31 48 44.56	31 48 44.42	31 48 44.53

Latitude of astronomical station at Frontera, Texas, = 31° 48′ 44″.53.

TABLE IX.*

Corrections to be applied to the results for latitude of astronomical station at Frontera, Texas, in order to introduce the elements of the stars as observed at the Washington Observatory, in 1852 and 1853.

Number of pair.	Names of stars.	DECLINATIONS. B. A. C.	DECLINATIONS. Washington Observatory catalogue.	Difference.	½ differ'ce, or error for correction.	Number of pair.	Names of stars.	DECLINATIONS. B. A. C.	DECLINATIONS. Washington Observatory catalogue.	Difference.	½ differ'ce, or error for correction.
		° ′ ″	° ′ ″					° ′ ″	° ′ ″		
1	2194	25 16 27.2	....	....	....	13	3355	21 52 37.10	21 52 32.91	— 4.19	
	2270	38 15 10.2	....	....	....		3399	41 46 05.1	41 46 01.47	— 3.63	— 3.91
2	2444	11 57 33.9	....	....	....	14	3409	30 21 37.5	30 21 42.02	+ 4.52	
	2341	51 40 15.9	....	....	....		3427	33 22 15.4	33 22 08.45	— 6.95	— 1.21
3	2469	28 13 14.8	28 13 13.23	— 1.57		15	3671	23 58 20.1	23 58 19.01	— 1.09	
	2504	35 22 41.4	35 22 45.38	+ 3.98	+ 1.20		3584	39 41 26.0	39 41 26.85	+ 0.85	— 0.12
4	2472	28 13 18.2	....	....	....	16	3710	28 45 53.2	28 45 52.17	— 1.03	
	2504	35 22 41.4	....	....	....		3736	34 49 57.6	34 50 04.01	+ 6.41	+ 2.69
5	2605	19 42 13.3	19 42 15.82	+ 2.52		17	3842	23 54 44.6	23 54 44.11	— 0.49	
	2691	43 41 09.0	43 41 07.85	— 1.15	+ 0.69		3781	39 40 30.1	39 40 29.93	— 0.17	— 0.33
6	2788	21 13 04.8	21 13 00.04	— 4.76		18	3915	19 14 07.4	....	....	....
	2798	42 28 59.8	42 28 58.00	— 1.80	— 3.28		3952	44 27 23.9	....	....	....
7	2818	25 01 17.5	25 01 23.85	+ 6.35		19	3990	21 03 10.7	21 03 08.32	— 2.38	
	2855	38 31 42.2	38 31 33.85	— 8.35	— 1.00		3973	42 33 18.6	42 33 17.75	— 0.85	— 1.61
8	2952	31 14 16.0	31 14 13.21	— 2 79		20	4014	16 16 27.6	16 16 22.96	— 4.64	
	2912	32 28 07.5	32 28 04.07	— 3.43	— 3.11		4026	47 18 42.1	47 18 42.30	+ 0.20	— 2.22
9	3109	30 15 09.4	30 15 13.90	+ 4 50		21	4014	16 16 27.6	16 16 22.96	— 4.64	
	3033	33 29 02.8	33 29 00.84	— 1.96	+ 1.27		4028	47 18 17.6	47 18 16.34	— 1.26	— 2.95
10	3181	19 43 16.7	19 43 21.36	+ 4.66		22	4066	22 17 43.8	22 17 41.73	— 2.07	
	3131	43 49 57.8	43 49 56.25	— 1.55	+ 1.56		4126	41 29 46.1	41 29 45.67	— 0.43	— 1.25
11	3201	26 33 36.2	26 33 33.46	— 2.74		23	4141	23 52 08.2	23 52 07.81	— 0.39	
	3252	37 08 55.7	37 08 54.73	— 0.97	— 1.86		4188	39 51 02.6	39 51 06.39	+ 3.79	+ 1.70
12	3201	26 33 36.2	26 33 33.46	— 2.74		24	4212	21 43 43.3	21 43 39.31	— 3.99	
	3261	37 03 39.3	37 03 36.32	— 2.98	— 2.86		4258	41 42 03.4	41 42 03.67	+ 0.27	— 1.86

* The reference on page 193 to table IXa should be VIII.

TABLE X.

Result of observations on the prime vertical for latitude: By Lieut. A. W. Whipple, at Presidio de San Elceario.

Date.	Star observed.	Result from each observation.	Res'lt from mean of wires.	Date.	Star observed.	Result from each observation.	Res'lt from mean of wires.	Final result.
1851.		° ′ ″	° ′ ″	1851.		° ′ ″	° ′ ″	
Jan. 29	β Geminorum........	31 35 13.80		Feb. 3	2082 Aurigæ.........	31 35 12.73		Lat. of Presidio de San Elceario.. ° ′ ″ 31 35 12.616
		11.28	31 35 12.62			13.67	31 35 13.43	
		12.78				13.90		
	1768 Aurigæ......	10 54	11.32		1768 Aurigæ	12.49		
		12.10				13.55	12.99	
						12 93		
	2082 Aurigæ.......	11.87						
		09.35	10.63	Feb. 4	1768 Aurigæ	11.20		
		10.68				10.66	[illegible]	
						10.71		
Feb. 3	β Geminorum	[illegible]						
		13.96	13.80		2340 Geminorum....	17.39		
		14.90				14.14	15.18	
						13.95		

TABLE XI.

Tabulation of results for the latitude of astronomical station on the Rio Grande, near the mouth of the cañon, derived from observations made with zenith telescope No. 4, on twenty-one pairs of stars: By Major W. H. Emory, Chief Astronomer and Surveyor of United States and Mexican boundary survey.

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.
	B. A. C. 4594 S. 4627 N.	B. A. C. 4706 S. 4747 N.	B. A. C. 4810 S. 4783 N.	B. A. C. 4873 S. 4841 N.	B. A. C. 5048 S. 4958 N.	B. A. C. 5223 S. 5092 N.	B. A. C. 5234 S. 5287 N.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1852, June 24................	31 02 20.04	31 02 26.01	31 02 27.73	31 02 28.16	31 02 31.35	31 02 23.79	31 02 28.00
25..................	31 02 30.20	31 02 28.49	31 02 26.49	31 02 27.37	31 02 31.26	31 02 21.76	31 02 24.00
26..................	....	31 02 22.10	....	31 02 30.45	21 02 23.19	....	....
Latitude by a mean of each pair.	31 02 25.12	31 02 25.53	31 02 27.11	31 02 28.66	31 02 28.60	31 02 22.78	31 02 26.00
Corrections for declinations....	— 2 53	— 0.37	0.00	+ 1.02	— 3.93	0.00	0.00
Corrected latitude.............	31 02 22.59	31 02 25.16	31 02 27.11	31 02 29.68	31 02 24.67	31 02 22.78	31 02 26.00

TABLE XI—Continued.

Date.	8th pair.	9th pair.	10th pair.	11th pair.	12th pair.	13th pair.	14th pair.
	B. A. C. 5541 S. 5473 N.	B. A. C. 5652 S. 5693 N.	B. A. C. 5732 S. 5706 N.	B. A. C. 5828 S. 5895 N.	B. A. C. 5841 S. 5795 N.	B. A. C. 5860 S. 5886 N.	B. A. C. 5962 S. 5927 N.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1852, June 24............	31 02 26.95	31 02 24.83	....	31 02 27.53	....	....	....
25..................	31 02 29.16	31 02 24.44	31 02 28.85	....	31 02 29.28	31 02 26.96	31 02 27.10
26..................	....	31 02 26.33	....	....	31 02 27.17	31 02 25.62	31 02 27.54
Latitude by a mean of each pair.	31 02 28.05	31 02 25.20	31 02 28.85	31 02 27.53	31 02 28.23	31 02 26.29	31 02 27.32
Corrections for declinations....	0.00	— 1.25	0.00	0.00	+ 0.32	+ 0.05	0.00
Corrected latitude.............	31 02 28.05	31 02 23.95	31 02 28.85	31 02 27.53	31 02 28.55	31 02 26.34	31 02 27.32

TABLE XI—Continued.

Date.	15th pair. B. A. C. 5962 S. 5980 N.	16th pair. B. A. C. 6147 S. 6178 N.	17th pair. B. A. C. 6241 S. 6349 N.	18th pair. B. A. C. 6322 S. 6355 N.	19th pair. B. A. C. 6341 S. 6355 N.	20th pair. B. A. C. 6453 S. 6390 N.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1852, June 24	31 02 28.02	31 02 27.92	31 02 27.99	....	....	31 02 28.98
25	31 02 27.32	31 02 28.91	....	31 02 23.42	31 02 22.59	31 02 26.73
26	31 02 26.70	31 02 26.38	....	31 02 23.98	31 02 23.54	31 02 26.34
Latitude by a mean of each pair.	31 02 27.35	31 02 27.74	31 02 27.99	31 02 23.70	31 02 23.06	31 02 27.35
Corrections for declinations	0.00	— 1.96	— 0.82	+ 0.99	+ 1.47	— 1.75
Corrected latitude	31 02 27.35	31 02 25.78	31 02 27.17	31 02 24.69	31 02 24.53	31 02 25.60

TABLE XI—Continued.

Date.	21st pair. B. A. C. 6453 S. 6391 N.	Results for latitude by a mean of each night, (declina's correctd.)	1st result. Lat. by a mean of all the pairs, (declinations corrected.)	2d result. Lat. by a mean of all the observations, (declinations corrected.)	3d result. Lat. by a mean of results for each night, (declinations corrected.)	Final result, (being a mean of 1st, 2d, 3d results.)
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1852, June 24	31 02 27.05	31 02 26.06				
25	31 02 28.71	31 02 26.48				
23	31 02 26.41	31 02 25.27				
Latitude by a mean of each pair.	31 02 27.39					
Corrections for declinations	— 1.75					
Corrected latitude	31 02 25.64		31 02 26.15	31 02 26.02	31 02 26.27	31 02 26.15

Latitude of astronomical station on the Rio Grande, near mouth of the cañon.................... = 31° 02′ 26″.15

TABLE XI*a*.

Corrections to be applied to the results for latitude of astronomical station on the Rio Grande, near mouth of the cañon, in order to introduce the elements of the stars given in the Twelve-Year Catalogue.

Number of pair.	Names of stars.	DECLINATIONS. B. A. C.	DECLINATIONS. T. Y. C.	Difference.	½ difference or error for correction.
		° ′ ″	° ′ ″		
1	4594	26 27 29.2	26 27 24.14	— 5.06	— 2.53
	4627	35 31 04.1			
2	4706	25 48 17.5	25 48 16.77	— 0.73	— 0.37
	4747	36 12 14.7			
3	4810	22 55 24.2	....	....	....
	4783	39 04 23.0	....	....	....
4	4873	17 36 10.4			
	4841	44 17 27.1	44 17 29.13	+ 2.03	+ 1.02
5	5048	21 07 34.4	21 07 27.45	— 6.95	
	4958	40 59 06.0	40 59 05.09	— 0.91	— [illegible]
6	5223	14 34 47.7	....	....	....
	5092	47 35 29.2	....	....	....
7	5234	18 36 31.6	....	....	....
	5287	43 34 40.2	....	....	....
8	5541	30 49 01.4	....	....	....
	5473	31 14 37.7	....	....	....
9	5652	30 13 26.6			
	5693	31 57 12.8	31 57 10.31	— 2.49	— 1.25
10	5732	15 10 24.9	....	....	....
	5706	46 47 03.1	....	....	....
11	5828	25 01 40.2	....	....	....
	5895	37 05 21.0	....	....	....

Number of pair.	Names of stars.	DECLINATIONS. B. A. C.	DECLINATIONS. T. Y. C.	Difference.	½ difference or error for correction.
		° ′ ″	° ′ ″		
12	5841	11 01 51.4	11 01 52.04	+ 0.64	+ 0.32
	5795	51 02 06.1			
13	5860	24 39 07.2	24 39 07.30	+ 0.10	+ 0.05
	5886	37 17 14.3			
14	5962	30 52 52.2	....	....	....
	5927	31 16 27.0	....	....	....
15	5962	30 32 52.3	....	....	....
	5980	[illegible] 15.0	....	....	....
16	6147	30 32 37.4			
	6178	31 22 19.7	31 22 15 77	— 3.93	— 1.96
17	6241	23 12 47.1	23 12 45 13	— 1.97	
	6349	38 46 31.4	38 46 31.74	+ 0.34	— 0.82
18	6322	23 30 30.9	23 30 30.14	— 0.76	
	6355	38 38 46.4	38 38 49.14	+ 2.74	+ 0.99
19	6341	23 29 14.9	23 29 15.11	+ 0.21	
	6355	38 38 46.4	38 38 49.14	+ 2.74	+ 1.47
20	6453	22 27 34.5	22 27 30.99	— 3.51	— 1.75
	6390	39 30 57.2			
21	6453	22 27 34.5	22 27 30.99	— 3.51	— 1.75
	6391	39 27 29.9			

TABLE XII.

Tabulation of results for the latitude of astronomical station opposite Presidio del Norte, derived from observations made with zenith telescope No. 4, on twenty-six pairs of stars: By Major W. H. Emory, Chief Astronomer and Surveyor of the United States and Mexican boundary survey.

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.
	B. A. C. 4993 S. 5072 N.	B. A. C. 5048 S. 5084 N.	B. A. C. 5132 S. 5122 N.	B. A. C. 5132 S. 5130 N.	B. A. C. 5146 S. 5168 N.	B. A. C. 5273 S. 5295 N.	B. A. C. 5426 S. 5460 N.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1852, July 15	29 34 07.15	....	29 34 07.16	29 34 06.89	....	29 34 08.32	29 34 03.90
16	29 34 08.49	....	29 34 08.30	29 34 08.77	....	29 34 07.42	29 34 04.46
18	....	29 34 11.00	....	....	29 34 09.50	29 34 06.71	29 34 04.77
21	....	....	....	....	....	....	29 34 05.26
22	....	....	....	....	....	29 34 07.53	....
Aug. 10	....	....	....	....	....	....	....
12	....	....	....	....	....	....	....
18	....	....	....	....	....	....	....
Latitude by a mean of each pair.	29 34 07.82	29 34 11.00	29 34 07.73	29 34 07.83	29 34 09.50	29 34 07.49	29 34 04.60
Corrections for declinations....	— 0.96	— 2.74	0.00	0.00	— 1.10	— 0.60	0.00
Corrected latitude.	29 34 06.86	29 34 08.26	29 34 07.73	29 34 07.83	29 34 08.40	29 34 06.89	29 34 04.60

TABLE XII—Continued.

Date.	8th pair.	9th pair.	10th pair.	11th pair.	12th pair.	13th pair.	14th pair.
	B. A. C. 5527 S. 5546 N.	B. A. C. 5677 S. 5619 N.	B. A. C. 5883 S. 5788 N.	B. A. C. 5900 S. 5929 N.	B. A. C. 6021 S. 5986 N.	B. A. C. 6150 S. 6087 N.	B. A. C. 6241 S. 6235 N.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1852, July 15	....	....	29 34 06.86	....	29 34 08.74	....	....
16	29 34 05.54	29 34 04.11	29 34 06.50	29 34 04.90	....	29 34 08.21	29 34 07.82
18	29 34 06.34	29 34 03.93	....	29 34 03.97	29 34 09.05	29 34 08.17	29 34 07.24
21	29 34 04.93	29 34 04.19	29 34 06.42	29 34 04.71	29 34 09.58	29 34 07.50	29 34 07.88
22	29 34 06.42	29 34 03.82	29 34 07.31	29 34 05.49	29 34 08.49	29 34 07.74	29 34 07.49
Aug. 10	....	29 34 02.55	....	29 34 03.09	29 34 08.69	29 34 07.87	29 34 05.69
12	....	29 34 02.71	29 34 06.85	29 34 04.27	29 34 08.76	29 34 07.62	29 34 06.20
18	....	29 34 02.50	29 34 06.42	29 34 03.70	29 34 08.00	29 34 06.93	29 34 07.58
Latitude by a mean of each pair.	29 34 05.81	29 34 03.40	29 34 06.73	29 34 04.30	29 34 08.76	29 34 07.72	29 34 07.12
Corrections for declinations....	0.00	0.00	+ 0.23	+ 1.69	0.00	+ 0.10	— 1.08
Corrected latitude.	29 34 05.81	29 34 03.40	29 34 06.96	29 34 05.99	29 34 08.76	29 34 07.82	29 34 06.04

TABLE XII—Continued.

Date.	15th pair.	16th pair.	17th pair.	18th pair.	19th pair.	20th pair.	21st pair.	22d pair.
	B. A. C. 6387 S. 6349 N.	B. A. C. 6387 S. 6355 N.	B. A. C. 6453 S. 6466 N.	B. A. C. 6589 S. 6599 N.	B. A. C. 6648 S. 6740 N.	B. A. C. 6673 S. 6740 N.	B. A. C. 6714 S. 6740 N.	B. A. C. 6794 S. 6817 N.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1852, July 15	....	....	....	....	....	....	....	....
16	29 34 07.24	29 34 07.70	....	29 34 08.47	29 34 07.01	29 34 06.48	29 34 06.40	....
18	29 34 05.59	29 34 05.53	29 34 09.97	29 34 08.60	29 34 06.87	29 34 07.61	29 34 07.53	29 34 09.29
21	29 34 07.48	29 34 08.16	29 34 09.55	29 34 08.88	29 34 07.92	....	....	29 34 09.63
22	29 34 06.65	29 34 07.22	29 34 09.79	29 34 08.79	....	....	....	....
Aug. 10	29 34 05.46	29 34 06.06	....	29 34 08.48	29 34 05.73	29 34 04.90	29 34 04.85	29 34 09.88
12	29 34 04.40	29 34 05.82	....	29 34 08.60	29 34 05.35	29 34 05.38	29 34 06.49	29 34 07.04
18	29 34 05.46	29 34 06.36	....	29 34 09.68	29 34 06.49	29 34 05.81	29 34 06.04	29 34 09.29
Latitude by a mean of each pair.	29 34 06.04	29 34 06.69	29 34 09.77	29 34 08.79	29 34 06.56	29 34 06.04	29 34 06.26	29 34 09.02
Corrections for declinations	— 0.01	+ 1.45	— 1.71	+ 0.39	+ 0.09	0.00	0.00	+ 0.24
Corrected latitude	29 34 06.03	29 34 08.14	29 34 08.06	29 34 09.18	29 34 06.65	29 34 06.04	29 34 06.26	29 34 09.26

TABLE XII—Continued.

Date.	23d pair.	24th pair.	25th pair.	26th pair.	Results for latitude by a mean of each night. (declinations corrected.)	1st result.	2d result.	3d result.
	B. A. C. 6882 S. 6851 N.	B. A. C. 6883 S. 6851 N.	B. A. C. 6973 S. 7029 N.	B. A. C. 6978 S. 7029 N.		Lat. by a mean of all the pairs, (declinations corrected.)	Lat. by a mean of all the observations, (declinations corrected.)	Lat. by a mean of results for each night, (declinat'ns corrected.)
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″
1852, July 15	....	....	....	....	29 34 07.19			
16	....	....	....	....	29 34 07.00			
18	29 34 07.60	29 34 05.45	29 34 10.14	29 34 10.54	29 34 07.37			
21	29 34 07.61	29 34 06.07	29 34 10.15	29 34 09.89	29 34 07.62			
22	....	....	....	....	29 34 07.27			
Aug. 10	29 34 07.07	....	29 34 09.79	29 34 09.64	29 34 06.84			
12	29 34 06.75	....	29 34 08.31	29 34 08.90	29 34 06.65			
18	29 34 07.36	....	....	....	29 34 06.76			
Latitude by a mean of each pair.	29 34 07.28	29 34 05.76	29 34 09.60	29 34 09.74				
Corrections for declinations	0.00	0.00	0.00	0.00				
Corrected latitude	29 34 07.28	29 34 05.76	29 34 09.60	29 34 09.74	....	29 34 07.21	29 34 07.08	29 34 07.09

Latitude of astronomical station opposite Presidio del Norte, (mean of 1st, 2d, and 3d results)........ = 29° 34′ 07″.13

TABLE XII *a*.

Corrections to be applied to the results for latitude of astronomical station at Presidio del Norte, in order to introduce the elements of the stars, as given in the Twelve-Year Catalogue.

Number of pairs.	Names of stars.	DECLINATIONS. B. A. C.	DECLINATIONS. T. Y. C.	Difference.	½ difference or error for correction.	Number of pairs.	Names of stars.	DECLINATIONS. B. A. C.	DECLINATIONS. T. Y. C.	Difference.	½ difference or error for correction.
		° ′ ″	° ′ ″					° ′ ″	° ′ ″		
1	4993	25 40 49.73	25 40 47.81	— 1.92	— 0.96	14	6241	23 12 57.13	23 12 55.32	— 1.81	
	5072	33 28 09.53	……	……	……		6235	36 00 11.14	36 00 10.78	— 0.36	— 1.08
2	5048	21 07 15.76	21 07 08.88	— 6.88		15	6387	20 24 36.31	……	……	……
	5084	37 54 06.16	37 54 07.55	+ 1.39	— 2.74		6349	38 46 44.14	38 46 44.11	— 0.03	— 0.01
3	5132	17 38 30.43	……	……	……	16	6387	20 24 36.31	……	……	……
	5122	41 20 38.50	……	……	……		6355	38 39 00.22	38 39 03.12	+ 2.90	+ 1.45
4	5132	17 38 30.43	……	……	……	17	6453	22 27 49.68	22 27 46.25	— 3.43	— 1.71
	5130	41 24 29.02	……	……	……		6466	36 42 57 25	……	……	……
5	5146	18 09 15.41	18 09 13.21	— 2.20		18	6589	21 08 06.41	……	……	……
	5168	30 50 29.15	30 50 29.15	0.00	— 1.10		6599	37 52 27.96	37 52 28.73	+ 0.77	+ 0.39
6	5273	20 45 01.84	20 45 00.64	— 1.20	— 0.60	19	6648	29 20 12.04	29 20 12.21	+ 0.17	+ 0.09
	5295	38 22 50.69	……	……	……		6740	29 48 59.30	……	……	……
7	5426	19 11 12.58	……	……	……	20	6673	29 09 10.83	……	……	……
	5460	40 04 07.93	……	……	……		6740	29 48 59.30	……	……	……
8	5527	20 48 31.11	……	……	……	21	6714	29 08 29.66	……	……	……
	5546	38 24 04.27	……	……	……		6740	29 48 59.30	……	……	……
9	5677	24 54 37.16	……	……	……	22	6794	18 46 35.30	……	……	……
	5619	34 18 58.74	……	……	……		6817	40 13 37.25	40 13 37.73	+ 0.48	+ 0.24
10	5883	23 06 13.03	23 06 13.50	+ 0.47	+ 0.23	23	6882	24 23 40.51	……	……	……
	5788	36 07 59.98	……	……	……		6851	34 41 36.22	……	……	……
11	5900	20 12 40.87	20 12 44.25	+ 3.38	+ 1.69	24	6883	24 31 41.36	……	……	……
	5929	38 59 54.13	……	……	……		6851	34 41 36.22	……	……	……
12	6021	27 48 46.56	……	……	……	25	6973	27 21 53.92	……	……	……
	5986	31 17 13.05	……	……	……		7029	31 43 00.37	……	……	……
13	6150	28 44 52.29	28 44 51.82	— 0.47		26	6978	27 19 29.98	……	……	……
	6087	30 12 24.00	30 12 24.66	+ 0.66	+ 0.10		7029	31 43 00.37	……	……	……

TABLE XIII.

Results for latitude of Eagle Pass, from observations made with sextant, by Lieut. Michler, in 1852.

AUGUST 19.				AUGUST 20.			
Polaris.		ε Sagittarii.		Polaris.		ε Sagittarii.	
	° ′ ″		° ′ ″		° ′ ″		° ′ ″
	28 48 17.6		26 55 57.9		28 48 37.9		26 55 43.3
	28 48 41.9		26 56 14.7		28 48 43.5		26 55 48.2
	28 48 31.1		26 56 05.4		28 48 39.8		26 55 56.5
	28 48 31.8		26 56 06.4		28 48 37.1		26 56 17 6
	28 48 30.2		26 56 03.0				26 56 06.7
	28 48 21.0		26 56 10.4	Sum .... =4)	158.3		26 56 07.2
	28 48 29.9		26 56 07.8				26 56 12.6
			26 56 05.8	Mean............ =	28 48 39.6		26 56 05.1
Sum .... =7)	203.5		26 55 59.0	Corr. for refraction. =	1 32.26		26 56 10.4
			26 55 54.8				26 56 22.7
Mean.............. =	28 48 29.07		26 56 01.5	Lat. by Polaris.... =	28 47 07.3		26 56 17.8
Corr. for refraction.. =	1 32.00		26 56 10.2				26 56 11.0
							26 55 51.9
Lat by Polaris...... =	28 46 57.07	Sum .... =12)	672 56.9				26 55.38.0
							26 56 06.0
		Mean............. =	26 56 04.7				
		Corr. for refraction. =	1 39.17			Sum .... =15)	840 55.0
		Meridian altitude.. =	26 54 25 53			Mean............. =	26 56 03.7
		Star's decl'n (S)... =	34 26 57.30			Corr. for refraction. =	1 39.18
			61 21 22.83			Meridian altitude.. =	26 54 24.52
			90 00 00.00			Star's decl'n (S)... =	34 26 57.00
		Lat. by 12 obs'ns.. =	28 38 37.17				61 21 21.52
		Lat. by observat'ns on Polaris...... =	28 46 57.07				90 00 00.00
						Lat. by ε Sagittarii. =	28 38 38.48
		Sum .... =2)	85 34.24			Lat. by Polaris.... =	28 47 07.34
		Latitude .... =	28 42 47.1			Sum .... =2)	57 25 45.82
						Latitude.......... =	28 42 52.91

TABLE XIII—Continued.

Result for latitudes of Eagle Pass—Continued.

SEPTEMBER 8.				SEPTEMBER 9.			
Polaris.		Fomalhaut.		Polaris.		Fomalhaut.	
	° ′ ″		° ′ ″		° ′ ″		° ′ ″
	28 47 10.2		30 57 58.03		28 46 41.3		30 58 01.8
	28 46 55.8		30 57 52.70		28 47 01.1		30 57 33.4
	28 46 59.8		30 57 48.64		28 47 11.7		30 57 40.9
	28 46 45.1		30 57 44.28		28 47 10.3		30 57 43.1
	28 46 55.0		30 57 41.95		28 47 22.5		30 57 47.3
	28 47 03.5		30 57 51.12				30 57 49.8
	28 47 04.0		30 57 54.99	Sum .... =5)	235 26.9		30 57 33.4
			30 57 58.79				30 57 30.9
Sum .... =7)	328 53.4		30 57 42.69	Mean............. =	47 05.4		30 57 28.4
			30 57 38.82	Lat. by mean of 5			30 57 30.0
Mean............... =	46 59.1		30 57 48.35	obs'ns on Polaris. =	28 47 05.4		30 57 19.5
Lat. by mean of 7 ob-			30 57 57.61				30 57 51.0
servat's on Polaris =	28 46 59.1		30 57 41.37				30 57 29.4
			30 57 44.23				30 57 16.6
			30 57 40 46				30 57 28.4
							30 57 20.0
		Sum .... =15)	724.03				30 57 23.5
							30 57 39.8
		Meridian altitude.. =	30 57 48.27				30 57 38.9
		Star's decl'n (S)... =	30 24 05.00				30 57 23.9
							30 57 59.4
			61 21 53.27				30 58 03.7
			90 00 00.00				
						Sum .... =22)	813.1
		Lat. by Fomalhaut. =	28 38 06.73			Meridian altitude... =	30 57 36.9
		Lat. by Polaris.. =	28 46 59.10			Star's decl'n (S.)... =	30 24 05.0
		Sum .... =2)	57 25 05.83				61 21 41.9
							90 00 00.0
		Latitude.......... =	28 42 32.91				
						Lat. by Fomalhaut.. =	28 38 18.1
						Lat. by Polaris ..... =	28 47 05.4
						Latitude............ =	28 42 41.7

Results for latitude of Eagle Pass, for each date of observation, in 1852.

		° ′ ″
Aug. 19	Latitude by 7 observations on Polaris....................................	= 28 46 57.07
	Latitude by 12 observations on ε Sagittarii....................................	= 28 38 37.17
	Sum....................................	= 2)57 25 34.24
	Latitude....................................	= 28 42 47.12
Aug. 20	Latitude by 4 observations on Polaris....................................	= 28 47 07.34
	Latitude by 15 observations on ε Sagittarii....................................	= 28 38 38.48
	Sum....................................	= 2)57 25 45.82
	Latitude....................................	28 42 52.91
Sept. 8	Latitude by 7 observations on Polaris....................................	= 28 46 59.10
	Latitude by 15 observations on Fomalhaut....................................	= 28 38 06.73
	Sum....................................	= 2)57 25 05.83
	Latitude....................................	= 28 42 32 91

TABLE XIII– Continued.

Results for latitude of Eagle Pass for each date of observation—Continued.

		° ′ ″
Sept. 9	Latitude by 5 observations on Polaris	= 28 47 05.40
	Latitude by 22 observations on Fomalhaut	= 28 38 18.10
	Sum	= 2)57 25 23.50
	Latitude	= 28 42 41.75

RECAPITULATION.

	° ′ ″
Latitude August 19, 1852	= 28 42 47.12
Do...August 20	= 28 42 52.91
Do...September 8	= 28 42 32.91
Do...September 9	= 28 42 41.75
Sum	= 4) 170 54 69
Mean	= 42 43.67

Latitude of Eagle Pass = 28° 42′ 43.″67.

TABLE XIV.

Tabulation of results for the latitude of astronomical station at Ringgold Barracks, derived from observations made with the zenith telescope No. 4, on thirty-two pairs of stars: By Major W. H. Emory, Chief Astronomer and Surveyor of United States and Mexican boundary survey.

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.
	B. A. C. 4225 N. 4292 S.	B. A. C. 4367 S. 4433 N.	B. A. C. 4468 S. 4479 N.	B. A. C. 4468 S. 4536 N.	B. A. C. 4553 S. 4640 N.	B. A. C. 4566 S. 4640 N.	B. A. C. 4652 N. 4729 S.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1853, June 4	....	26 22 28.20	26 22 27.25	26 22 25.66	....	26 22 28.76	....
6	26 22 24.14	26 22 31.27	....	....	26 22 29.26	26 22 30.35	....
14	....	....	....	....	....	....	....
19	....	26 22 23.82	....	....	26 22 28.22	26 22 29.56	....
24	....	....	....	....	....	....	26 22 26.42
26	....	....	....	....	....	....	26 22 26.73
27	....	....	....	....	....	26 22 28.83	....
22	....	....	....	....	....	....	26 22 25.26
29	....	....	....	....	....	....	....
Latitude by a mean of each pair.	26 22 24.14	26 22 27.76	26 22 27.25	26 22 25.66	26 22 28.74	26 22 29.37	26 22 26.14
Corrections for declinations....	0.00	— 0.34	0.00	+ 0.49	0.00	0.00	0.00
Corrected latitude.	26 22 24.14	26 22 27.42	26 22 27.25	26 22 26.15	26 22 28.74	26 22 29.37	26 22 26.14

TABLE XIV—Continued.

Date.	8th pair.	9th pair.	10th pair.	11th pair.	12th pair.	13th pair.	14th pair.
	B. A. C. 4721 S. 4783 N.	G. C. 1147 S. 1163 N.	B. A. C. 4751 S. 4783 N.	B. A. C. 4864 N. 4953 S.	B. A. C. 4864 N. 4993 S.	G. C. 1273 N. 1281 S.	B. A. C. 5252 S. 5473 N.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1853, June 4	...	...	...	...	...	...	...
6	26 22 24.90	...	26 22 28.76	...	...	...	...
14	...	...	...	...	...	26 22 26.74	...
19	...	26 22 26.95	...	...	...	26 22 30.44	...
24	...	26 22 26.02	...	26 22 26.24	26 22 27.05	26 22 27.50	26 22 30.48
26	...	26 22 26.92	...	26 22 26.50	26 22 28.14	...	...
27	...	26 22 28.42	...	26 22 27.46	26 22 28.52	26 22 29.13	26 22 30.12
28	...	26 22 28.02	...	26 22 27.10	26 22 28.28	26 22 29.40	26 22 30.34
29	...	26 22 27.74	...	26 22 26.69	26 22 27.95	26 22 26.38	26 22 30.54
Latitude by a mean of each pair.	26 22 24.90	26 22 27.35	26 22 28.76	26 22 26.80	26 22 27.99	26 22 28.76	26 22 30.37
Corrections for declinations	0.00	0.00	— 3.40	+ 0.10	— 0.96	0.00	0.00
Corrected latitude	26 22 24.90	26 22 27.35	26 22 25.36	26 22 26.90	26 22 27.03	26 22 28.76	26 22 30.37

TABLE XIV—Continued.

Date.	15th pair.	16th pair.	17th pair.	18th pair.	19th pair.	20th pair.	21st pair.
	G. C. 1341 N. 1417 S.	B. A. C. 5452 S. 5473 N.	G. C. 1352 N. 1417 S.	G. C. 1353 N. 1417 S.	G. C. 1369 N. 1415 S.	B. A. C. 5716 S. 5834 N.	B. A. C. 5716 S. 5895 N.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1853, June 4	...	...	...	...	...	...	...
6	...	...	...	...	...	...	...
14	26 22 29.38	...	26 22 30.94	26 22 30.20	...	...	...
19	26 22 30.76	...	26 22 31.40	26 22 30.74	...	26 22 26.69	26 22 25.98
24	...	26 22 30.63	...	...	26 22 28.19	26 22 27.15	26 22 25.07
26	...	...	...	...	...	26 22 30.27	26 22 25.94
27	...	26 22 30.98	...	...	26 22 30.02	26 22 25.39	26 22 24.67
28	...	26 22 30.16	...	...	26 22 29.73	26 22 24.85	26 22 24.46
29	...	26 22 31.74	...	...	26 22 29.62	26 22 25.38	26 22 25.43
Latitude by a mean of each pair.	26 22 30.07	26 22 30.88	26 22 31.17	26 22 30.47	26 22 29.39	26 22 26.62	26 22 25.26
Corrections for declinations	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrected latitude	26 22 30.07	26 22 30.88	26 22 31.17	26 22 30.47	26 22 29.39	26 22 26.62	26 22 25.26

TABLE XIV—Continued.

Date.	22d pair. B. A. C. 5941 S. 6062 N.	23d pair. B. A. C. 5941 S. 6068 N.	24th pair. G. C. 1554 S. 1596 N.	25th pair. B. A. C. 6428 N. 6460 S.	26th pair. G. C. 1652 N. 1736 S.	27th pair. N. 1652 G. C. S. 6663 B. A. C.	28th pair. B. A. C. 6460 S. 6476 N.	29th pair. B. A. C. 6495 N. 6528 S.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1853, June 4	....	....	....	....	....	....	....	....
6	....	....	....	....	....	....	....	....
14	....	....	26 22 28.42	....	26 22 28.68	26 22 27.66	....	....
19	....	....	26 22 26.72	....	....	....	....	....
24	26 22 26.39	26 22 27.43	26 22 27.31	....	26 22 28.55	....	....	....
26	26 22 25.99	26 22 26.60	26 22 26.87	26 22 25.78	....	....	26 22 28.09	....
27	26 22 28.30	26 22 28.26	26 22 28.84	....	....	....	26 22 29.35	26 22 26.56
28	26 22 27.25	26 22 27.72	26 22 27.37	26 22 27.31	....	....	26 22 28.53	26 22 28.35
29	26 22 27.43	26 22 28.17	26 22 28.36	26 22 26.98	....	....	26 22 30.32	....
Latitude by a mean of each pair	26 22 27.08	26 22 27.64	26 22 27.70	26 22 26.69	26 22 28.61	26 22 27.66	26 22 29.07	26 22 27.45
Corrections for declinations	− 0.86	− 0.86	0.00	+ 1.53	0.00	0.00	− 0.60	− 0.24
Corrected latitude	26 22 26.22	26 22 26.78	26 22 27.70	26 22 28.22	26 22 28.61	26 22 27.66	26 22 28.47	26 22 27.21

TABLE XIV—Continued.

Date.	30th pair. B. A. C. 6642 S. 6667 N.	31st pair. B. A. C. 6647 S. 6667 N.	32d pair. B. A. C. 6745 N. 6772 S.	Results for lat. by a mean of each night, (decl'ns corrected.)	1st result. Lat. by a mean of all the pairs, (decl'ns corrected.)	2d result. Lat. by a mean of all the observat'ns, (decl'ns corr'd.)	3d result. Lat. by a mean of results for each night, (dec. corr'd.)	Final result. Being a mean of 1st, 2d, and 3d results.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1853, June 4	....	....	....	26 22 27.51				
6	....	....	....	26 22 27.49				
14	....	....	....	26 22 29.29				
19	....	....	....	26 22 28.30				
24	....	....	....	26 22 27.28				
26	26 22 30.49	26 22 31.76	26 22 26.55	26 22 27.35				
27	26 22 28.66	....	26 22 28.41	26 22 28.[illegible]				
28	26 22 29.22	....	26 22 27.29	26 22 27.72				
29	26 22 30.28	....	26 22 27.84	26 22 28.09				
Latitude by a mean of each pair	26 22 29.66	26 22 31.76	26 22 27.52					
Corrections for declinations	0.00	− 2.37	+ 0.22					
Corrected latitude	26 22 29.66	26 22 29.39	26 22 27.74	....	26 22 27.86	26 22 27.60	26 22 27.91	26 22 27.79

Latitude of astronomical station at Ringgold Barracks = 26° 22′ 27″.79.

TABLE XIV *a*.

Corrections to be applied to the results for latitude of astronomical station at Ringgold Barracks, in order to introduce the elements of the stars, as given in the Twelve-Year Catalogue.

Number of pair.	Names of stars.	DECLINATIONS. B. A. C.	DECLINATIONS. T. Y. C.	Difference.	½ difference, or error for correction.	Number of pair.	Names of stars.	DECLINATIONS. B. A. C.	DECLINATIONS. T. Y. C.	Difference.	½ difference, or error for correction.
		° ′ ″	° ′ ″					° ′ ″	° ′ ″		
1	4285	40 05 39.5	......	......	......	17	1352	......	34 09 18.85	......	......
	4292	12 46 43.5	......	......	......		1417	......	18 41 37.79	......	......
2	4367	11 46 01.7	......	......	......	18	1353	......	34 03 19.08	......	......
	4433	40 56 55.0	40 56 54.32	— 0.68	— 0.34		1417	......	18 41 37.79	......	......
3	4468	11 56 20.9	......	......	......	19	1369	......	42 12 52.35	......	......
	4479	37 49 06.2	......	......	......		1415	......	10 26 01.70	......	......
4	4468	14 56 20.9	......	......	......	20	5716	15 40 48.9	......	......	......
	4536	37 57 07.1	37 57 08.08	+ 0.98	+ 0.49		5834	36 58 54.5	......	......	......
5	4553	23 17 50.3	......	......	......	21	5716	15 40 48.9	......	......	......
	4640	29 23 14.1	......	......	......		5895	37 05 21.0	......	......	......
6	4566	23 15 32.2	......	......	......	22	5941	12 40 25.9	12 40 24.18	— 1.72	— 0.86
	4640	29 23 14.1	......	......	......		6062	40 01 00.3	......	......	......
7	4652	32 45 57.9	......	......	......	23	5941	12 40 25.9	12 40 24.18	— 1.72	— 0.86
	4729	19 57 56.3	......	......	......		6068	40 02 18.3	......	......	......
8	4721	13 39 55.5	......	......	......	24	1554	......	16 45 48.19	......	......
	4783	39 04 23.0	......	......	......		1596	......	35 59 58.41	......	......
9	1147	......	13 41 56.70	......	......	25	6428	48 35 49.0	48 35 53.28	+ 4.28	......
	1163	......	38 57 59 91	......	......		6460	4 00 47.1	4 00 45.89	— 1.21	+ 1.53
10	4751	13 42 03.5	13 41 56.70	— 6.80	— 3.40	26	1652	......	33 11 29.68	......	......
	4783	39 04 23.0	......	......	......		1736	......	19 30 28.82	......	......
11	4864	27 10 06.4	......	......	......	27	1652	......	33 11 29.68	......	......
	4953	25 36 12.5	25 36 12.70	+ 0.20	+ 0.10		6663	19 35 46.5	......	......	......
12	4864	27 10 06.4	......	......	......	28	6460	4 00 47.1	4 00 45.89	— 1.21	— 0.60
	4993	25 41 08.8	25 41 06.88	— 1.92	— 0.96		6476	48 40 27.0	......	......	......
13	1273	......	39 31 03.66	......	......	29	6495	39 00 44.9	......	......	......
	1281	......	......	......	......		6528	13 38 40.7	13 38 40.22	— 0.48	— 0.24
14	5252	21 25 58.6	......	......	......	30	6642	16 38 58.4	......	......	......
	5473	31 14 37.7	......	......	......		6667	36 01 14.5	......	......	......
15	1341	......	34 14 20.52	......	......	31	6647	16 40 08.0	16 40 03.25	— 4.75	— 2.37
	1417	......	18 41 37.79	......	......		6667	36 01 14.5			
16	5452	21 29 58.5	......	......	......	32	6745	42 28 27.6	......	......	......
	5473	31 14 37.7	......	......	......		6772	10 15 05.1	10 15 05.54	+ 0.44	+ 0.22

TABLE XV.

Tabulation of results for the latitude of astronomical station at the mouth of the Rio Bravo, derived from observations made with zenith telescope No. 4, on twenty pairs of stars: By Major W. H. Emory, Chief Astronomer and Surveyor of the United States and Mexican boundary survey.

Date.	1st pair.	2d pair.	3d pair.	4th pair.	5th pair.	6th pair.	7th pair.	8th pair.
	G. C. 1390 N. 1399 S.	G. C. 1577 N. 1597 S.	B. A. C. 5460 N. 5532 S.	B. A. C. 5367 S. 5432 N.	B. A. C. 5686 S. 5788 N.	B. A. C. 5716 S. 5788 N.	B. A. C. 5821 S. 5886 N.	B. A. C. 5929 N. 5941 S.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
August 5, 1853	25 57 21.82	25 57 19.50			25 57 23.75	25 57 21.77	25 57 23.67	
6, 1853	25 57 22.14	25 57 22.77	25 57 22.00		25 57 21 45	25 57 20.08	25 57 21.95	25 57 23.74
7, 1853	25 57 21.86	25 57 20.24	25 57 21.21	25 57 22.86	25 57 21.88	25 57 20.06	25 57 21.38	25 57 22.76
9, 1853	25 57 22.72	25 57 21.11					25 57 21.71	25 57 22.51
10, 1853	25 57 22.28	25 57 20.52	25 57 22.27		25 57 21.16	25 57 18.89	25 57 21.18	25 57 23.39
11, 1853	25 57 21.83	25 57 21.60					25 57 22.53	25 57 22.66
16, 1853	25 57 21.50	25 57 20.68			25 57 20.67	25 57 18.62	25 57 22.91	25 57 23.81
17, 1853	25 57 22.90	25 57 21.25				25 57 20.82	25 57 23.73	25 57 23.37
18, 1853	22 57 22.56	25 57 21.50					25 57 23.38	25 57 23.30
Latitude by a mean of each pair	25 57 22.18	25 57 21.02	25 57 21.83	25 57 22.86	25 57 21.78	25 57 20.04	25 57 22.49	25 57 23.19

TABLE XV—Continued.

Date.	9th pair.	10th pair.	11th pair.	12th pair.	13th pair.	14th pair.	15th pair.	16th pair.
	B. A. C. 6087 N. 6106 S.	B. A. C. 6365 N. 6482 S.	B. A. C. 6365 N. 6528 S.	G. C. 1805 N. 1850 S.	G. C. 1805 N. 1852 S.	G. C. 1710 N. 1756 S.	B. A. C. 6744 N. 6777 S.	B.A. C. 6851 N. 6868 S.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
August 5, 1853	25 57 23.56	25 57 20.52	25 57 21.88			25 57 21.85		25 57 24.32
6, 1853	25 57 21.70			25 57 23.73	25 57 23.45	25 57 20.44	25 57 23.27	
7, 1853	25 57 22.20	25 57 20.05	25 57 21.17	25 57 22.87	25 57 23.07	25 57 20.54	25 57 21.02	25 57 21.12
9, 1853	25 57 21.94	25 57 18.98	25 57 20.71		25 57 23.09	25 57 19.64	25 57 20.66	25 57 22.97
10, 1853	25 57 22.25	25 57 19.29	25 57 20.90		25 57 24.24	25 57 20.82		
11, 1853	25 57 22.86	25 57 21.15	25 57 22.13		25 57 22.47	25 57 20.19	25 57 20.93	25 57 21.52
16, 1853	25 57 22.00	25 57 19.40	25 57 19.85		25 57 22.22	25 57 19.35		25 57 21.97
17, 1853	25 57 22.80	25 57 21.56	25 57 22.03		25 57 23.83	25 57 20.69	25 57 21.17	25 57 22.63
18, 1853	25 57 21.62	25 57 20.92	25 57 22.00		25 57 23.71	25 57 19.82	25 57 21.45	25 57 22.70
Latitude by a mean of each pair	25 57 22.32	25 57 20.23	25 57 21.33	25 57 23.30	25 57 23.26	25 57 20.37	25 57 21.42	25 57 22.46

TABLE XV—Continued.

Date.	17th pair.	18th pair.	19th pair.	20th pair.	Results for lat. by a mean of each night, (decl'ns corrected.)	1st result.	2d result.	3d result.	Final result.
	B. A. C. 7222 S. 7254 N.	B. A. C. 7383 N. 7641 S.	B. A. C. 7559 N. 7796 S.	B. A. C. 7565 N. 7963 S.		Lat. by a mean of all the pairs, (dec. corr'd.)	Lat. by a mean of all the obs., (dec. corr'd.)	Lat. by a mean of results for each night, (dec. corr'd.)	Being a mean of 1st, 2d, and 3d results.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
August 5, 1853					25 57 22.26				
6, 1853	25 57 21.99	25 57 23.18	25 57 21.54	25 57 22.85	25 57 22.27				
7, 1853	25 57 21.60	25 57 22.02	25 57 20.10	25 57 22.34	25 57 21.52				
9, 1853	25 57 19.76	25 57 22.06	25 57 21.09	25 57 22.71	25 57 21.45				
10, 1853	25 57 22.26	25 57 22.82	25 57 21.63	25 57 22.36	25 57 21.65				
11, 1853	25 57 21.54	25 57 22.60	25 57 21.85		25 57 21.85				
16, 1853	25 57 21.18				25 57 21.09				
16, 1853	25 57 21.60				25 57 22.18				
18, 1853	25 57 21.85				25 57 22.07				
Lat. by a m'n of each pair	25 57 21.47	25 57 22.54	25 57 21.24	25 57 22.56		25 57 21.89	25 57 21.78	25 57 21.82	25 57 21.83

Latitude of astronomical station at the mouth of Rio Bravo.. = 25° 57′ 21″.83

E.

Table of latitudes and longitudes of points on and near the boundary between the U. States and Mexico.

Station.	Latitude north.	Determined. When.	Determined. How.	Long. west of Greenwich.	Determined. When	Determined. How.	Observer.
	° ′ ″			° ′ ″			
Camp Riley, (Major Emory's Astronomical Observatory.)	32 35 43.53	1849	Zenith telescope...	117 06 29.7	1849	Moon culminations.	W. H. Emory.
"East Base" Station	32 35 42.33	1849	Triangulation from Camp Riley.	117 06 29.7	1849	Triangulation from Camp Riley.	Do.
"West Base" Station	32 34 33.10	1849	....do..............	117 09 03.23	1849	....do..............	Do.
Monument No. 1, marking the initial point of boundary.	32 31 59.63	1849	....do..............	117 08 29.7	1849	....do..............	Do.
Monument No. 2, (Station 4)............	32 32 25.2	1849	....do..............	117 03 31.7	1849	....do..............	Do.
Station No. 1..........................	32 33 11.8	1849	....do..............	116 53 05.9	1849	....do..............	Do.
Station No. 7..........................	32 34 02.0	1849	....do..............	116 44 17.6	1849	....do..............	Do.
Boundary Peak (A.)	32 36 35.9	1849	....do..............	116 18 14.6	1849	....do..............	Do.
Camp 118, (San Pasqual)................	33 03 42.0	1846	Sextant	117 06 42.2	1846	Sextant......	Do.
Camp 114, (near Warner's Ranch)........	33 16 57.0	1846	....do..............	116 41 56.2	1846	....do..............	Do.
Camp 112, (Vallecito)	32 58 15.0	1846	....do..............	116 23 53.2	1846	....do..............	Do.
Camp 111 (Carrizo Creek)...............	32 52 33.0	1846	....do..............	116 00 22.2	1846	....do..............	Do.
First Wells............................	32 40 22.0	1846	....do..............	114 00 28.0	1846	....do..............	Do.
Station 46, (left bank of Rio Colorado, below junction of Rio Gila.)	32 43 48	1851	....do..............	114 39 58.2	1851	....do..............	Lieut. Whipple, Top. Engineers.
New initial point of boundary on Rio Colorado, 20 miles below the mouth of Rio Gila.	32 29 44.45	1855	Zenith telescope...	114 48 44.53	1855	Triangulation from mouth of Gila.	Lieut. Michler, Top. Engineers.
Monument (pyramid of cast iron) on Sonora line, near the Colorado.	32 29 01.48	1855	Triangulation from initial point.	114 46 14.43	1855	Triangulation from initial point.	Lieut. Michler.
Quitobaquita	31 56 26.57	1855	Zenith telescope....	112 52 25.73	1855	Moon culminations.	Capt. Jimenez.
Junction of Gila and Colorado..........	32 43 32.3	1849	Triangulation from observatory.	114 36 09.9	1849	Triangulation from observatory.	W. H. Emory.
Station No. 7, on Rio Gila.............	32 43 56.8	1852	Sextant............	114 25 33.7	1852	By survey	Do.
Station No. 8, on Rio Gila.............	32 44 29.2	1852	....do..............	114 19 35.7	1852	....do..............	Do.
Camp 105, on Rio Gila, (Emory's Recon.)	32 43 17	1846	....do..............	....	......	....	Do.
Station No. 9, on Rio Gila, (Emory's Reconnaissance.)	32 41 36.3	1852	....do..............	114 17 32.5	1852	By survey..........	Lieut. Whipple, Top Engineers.
Station No. 10, on Rio Gila............	32 40 25.2	1852	... do..............	114 13 20.0	1852	By survey	Do.
Station No. 11, on Rio Gila............	32 41 49.3	1852	....do.......... ...	114 00 33	1852	....do..............	Do.
Station No. 12, on Rio Gila............	32 42 39.7	1852	....do..............	113 58 15	1852	....do..............	Do.
Camp 103, on an island in the Gila, (Emory's Reconnaissance.)	32 43 38	1846	....do..............	....	......	....	W. H. Emory.
Station No. 13, on Rio Gila............	32 46 02.5	1852	....do..............	113 46 59	1852	By survey	Lieut. Whipple.
Station No. 14, on Rio Gila............	32 46 44.8	1852	....do..............	113 44 22	1852	....do..............	Do.
Station No. 15, on Rio Gila............	32 49 40.8	1852	....do..............	113 36 45	1852	....do..............	Do.
Camp No. 101, on Rio Gila. (Emory's Reconnaissance.)	32 55 52	1846	....do..............	....	......	....	W. H. Emory.
Station No. 16, on Rio Gila............	32 55 56.4	1852	....do..............	113 18 54	1852	....do..............	Lieut. Whipple
Station No. 17, of 1852, on Rio Gila, or station No. 42, of 1851.	32 58 58.6	1851–2	....do..............	113 11 15	1851–2	....do..............	Do.
Camp 99, on Rio Gila, (Emory's Reconnaissance.)	32 59.22.0	1846	....do..............	....	......	....	W. H. Emory.
Camp 97, between Pimos and Coco Maricopas Villages, (Emory's Reconnaissance.)	33 09.28.0	1846	....do..............	....	......	....	Do.
Camp 95, on the Gila, (Emory's Reconnaissance.)	33 04 21.0	1846	....do..............	....	......	....	Do.
Camp 93, on Rio Gila, (Emory's Reconnaissance.)	33 05 40.0	1846	....do..............	....	......	....	Do.
Camp 91, on the San Pedro, near its mouth, (Emory's Reconnaissance.)	32 57 43.0	1846	....do..............	....	......	....	Do.
Camp 89, Disappointment Creek, (Emory's Reconnaissance.)	33 14 54.0	1846	....do..............	....	......	....	Do.
Camp 87, on the San Francisco, about two miles from its mouth, (Emory's Reconnaissance.)	33 14 29.0	1846	....do..............	....	......	....	Do.

E.—*Table of Latitudes and Longitudes*—Continued.

Station.	Latitude north.	Determined. When.	Determined. How.	Long. west of Greenwich.	Determined. When.	Determined. How.	Observer.
	° ′ ″			° ′ ″			
Camp 86, on the San Francisco, about two miles from its mouth, (Emory's Reconnaissance.)	33 12 10.0	1846	Sextant	....	......	....	W. H. Emory.
Camp 83, on Rio Gila, (Emory's Reconnaissance.)	32 53 16.0	1846	....do........	....	......	....	Do.
Camp 81, on Rio Gila, (Emory's Reconnaissance.)	32 44 52.0	1846	....do........	....	......	....	Do.
Camp 80, on Rio Gila, (Emory's Reconnaissance.)	32 38 13.0	1846	....do........	....	......	....	Do.
Camp 78, first camp on the Rio Gila, (Emory's Reconnaissance.)	32 50 08.0	1846	....do........	....	......	....	Do.
Camp 77, Night Creek, (Emory's Reconnaissance.)	32 50 54.0	1846	....do........	....	......	....	Do.
Copper Mines..........................	32 47 53.1	1851	....do........	108 04 39.7	1851	Sextant...........	Lieut. Whipple.
Camp 75, in the mountains, between the del Norte and Copper Mines, (Emory's Reconnaissance.)	32 42 11.0	1846	....do........	....	......	....	W. H. Emory.
Camp 73, first camp after leaving Rio del Norte, (Emory's Reconnaissance.)	32 55 04.0	1846	....do........	....	......	....	Do.
Camp 70, east bank of Rio del Norte, (Emory's Reconnaissance.)	33 20 02.0	1846	....do........	....	......	....	Do.
Camp 68, west bank of Rio del Norte, (Emory's Reconnaissance.)	33 41 12.0	1846	....do........	....	......	....	Do.
Camp 65, west bank of Rio del Norte, about two miles below Lamitar, (Emory's Reconnaissance.)	34 07 39.0	1846	....do........	....	......	....	Do.
Camp 62, a little south of and about one mile west of Peralta, (Emory's Reconnaissance.)	34 48 33.0	1846	....do........	....	......	....	Do.
Camp at Peralta, near Señora Chavis's private chapel, (Emory's Reconnaissance.)	34 50 57.0	1846	... do........	....	......	....	Do.
Albuquerque	35 05 51.0	1853	....do........	106 37 52.0	1853	Moon's culminat'n.	Lieut. Whipple.
Camp on the Rio del Norte, near the Alameda, (Emory's Reconnaissance.)	35 11 20.0	1846	....do........	....	......	....	W. H. Emory.
Camp on the Rio del Norte, about one mile below San Felipe, (Emory's Reconnaissance.)	35 25 30.0	1846	....do........	....	......	....	Do.
Camp Santa Fé, (Emory's Reconnaissance.)	35 41 06.0	1846	....do........	....	......	....	Do.
Lieutenant Whipple's astronomical station, near Doña Ana.	32 22 13.4	1851	Transits over prime vertical.	106 50 11.25	1851	Signal flashes simultaneously obser'd at Frontera.	Lieut. Whipple.
Doña Ana (church).....................	32 23 13.8	1851	Survey...........	106 48 32.5	1851	Survey............	Do.
Initial point of parallel 32° 22′ in the channel of Rio Bravo.	32 22 00.0	1851	Triangulation from astronom'l station.	106 50 56.25	1851	Signal flashes.....	Do.
First monument west of Rio Bravo, on parallel 32° 22′.	32 22 00.0	1851	....do........	....	1851	Triangulation from astronom'l station.	Do.
Station No. 5 (near parallel 32° 22′)......	32 22 03.8	1851	....	....	1851	Flashes of gunpowder.	Do.
Station No. 8.....do.......do..........	32 22 13.4	1851	....	....	1851	....do...........	Do.
Station No. 9.....do.......do..........	32 22 20.7	1851	....	....	1851	....do...........	Do.
Station No. 11.....do.......do..........	32 22 25.6	1851	....	....	1851	....do...........	Do.
Station No. 12.....do.......do..........	32 22 31.1	1851	....	108 04 50	1851	....do...........	Do.
Ojo de Inez..	32 25 18.5	1851	Sextant...........	....	1851	Sextant	Do.
Sugar Loaf Camp, south of Station No. 18, on parallel 32° 22′.	32 20 21.8	1851	....do........	109 01 16.3	1851	....do...........	Do.
Camp Reed............................	32 05 09.6	1851	....do........	109 02 17	1851	....do...........	Do.
Dry Camp.............................	32 08 33.8	1851	....do........	109 11 45	1851	....do...........	Do.
Camp near Dos Cabazas del Chiricahui...	32 08 43.7	1851	....do........	109 24 45	1851	....do...........	Do.
General Conde's Camp, Salt Lake, September 6th and 7th.	32 03 51.0	1851	....do........	109 47 10	1851	....do...........	Do.

E.—*Table of Latitudes and Longitudes*—Continued.

Station.	Latitude north.	Determined. When	Determined. How.	Long. west of Greenwich.	Determined. When	Determined. How.	Observer.
	° ′ ″			° ′ ″			
Camp, Salt Lake Spring, October 14, 1851.	32 02 38.8	1851	Sextant	…	1851	Sextant	Lieut. Whipple.
Señor Salazar's terminal point of parallel 32° 22′.	32 22 01.0	1851	…	109 50 56.25	1851	Moon culminations.	Do.
Camp near terminal point	32 22 06.6	1851	Sextant	109 50 15.75	1851	Sextant	Do.
Castro Spring	32 25 54.6	1851	do.	109 48 35.2	1851	do.	Do.
Pools in valley of Saos, bed of Rio Santo Domingo.	32 40 05.7	1851	do.	109 33 20	1851	do.	Do.
Quercus Cañon	31 56 15.0	1851	do.	110 08 35.0	1851	do.	Do.
First station on Rio San Pedro	31 54 31.2	1851	do.	110 11 52.0	1851	do.	Do.
San Pedro Springs	31 50 52.0	1851	do.	110 12 16.5	1851	Moon culminations.	Do.
Tucson astronomical station	32 12 32.0	1852	do.	110 53 10.0	[illegible]	Sextant	Do.
Tucson (church)	32 12 54.5	1852	Survey	110 52 55	1852	do.	Do.
Station 6 miles north of Tubac	31 41 58.53	1852	Sextant	110 57 06	[illegible]	do.	Do.
Tubac	…	1852	Survey	110 57 50	[illegible]	do.	Do.
Station near the mission of Tomocacori	31 34 47.16	1855	Sextant	110 56 57.90	[illegible]	do.	Capt Jimenez.
Ojo del Sopori	31 43 54.89	1855	do.	…	…	…	
Bamori	31 39 40.87	1855	do.	111 11 04.05	1855	Sextant	Do.
Hacienda of Aribaca	31 35 02.30	1855	do.	111 14 12.60	1855	do.	Do.
Las Boquillas	31 39 27.15	1855	do.	…	1855	do.	Do.
Near the Sierra de la Arteza	31 53 06.76	1855	do.	…	1855	do.	Do.
Station upon the road, July 15th	31 46 58.64	1855	do.	111 47 03.45	1855	do.	Do.
Station upon the road between Cobota and Sierra de la Nariz.	31 43 37.03	1855	do.	112 14 02.55	1855	do.	Do.
Station upon the road, July 18th	31 52 24.74	1855	do.	…	…	…	Do.
Altar (Sonora)	30 42 44.26	1854	do.	111 44 12.0	1854	do.	Do.
* Los Nogales	31 21 00.1	1855	Zenith telescope	110 51 02.1	[illegible]	Moon culminations.	J. H. Clark.
Astron'l station at head of Santa Cruz river	31 17 56.28	1855	do.	…	…	…	Do.
Santa Cruz, (church)	31 13 22.5	1852	Survey from astronomical station.	110 30 27.5	1855	Survey	Lat. by Lt. Whipple and long. by the survey of United States boundary commiss'n.
Agua Prieta Ravine	31 18 23.5	1852	Sextant	109 33 35.0	1855	do.	Do. do.
San Bernardino	31 19 40.35	1855	Zenith telescope	…	…	…	J. H. Clark.
San Luis Spring	31 20 32.88	1855	do.	…	…	…	Do.
Agua del Perro	31 20 57.56	1855	do.	…	…	…	Do.
Espia	31 20 56.43	1855	do.	…	…	…	Do.
Carrizalillo	31 50 55.26	1855	do.	…	…	…	Do.
Janos	30 52 00.0	1852	Sextant	…	…	…	Lieut. Whipple.
Corralitos	30 42 25.0	1852	do.	…	…	…	Do.
Fort Fillmore, (astronomical station)	32 13 34.8	1852	do.	…	[illegible]	Survey	W. H. Emory.
Fort Fillmore, (officers' quarters)	32 13 38.5	1852	Survey from astronomical station.	106 42 15.0	1852	do.	Do.
Frontera, (Maj. Emory's observatory)	31 48 44.31	1852	Zenith telescope	106 33 04.5	1851-2	Moon culminations.	Do.
Astronomical station, near initial point of boundary, (parallel 31° 47′.)	31 04 00.0	1854-5	do.	…	…	…	J. H. Clark.
Initial point in river, on parallel 31° 47′	31 47 00.0	1855	do.	106 31 20.8	[illegible]	Triangulation from Frontera.	Do.
Monument near initial point, on right bank of river.	31 47 00.0	[illegible]	do.	106 31 23.5	1855	do.	Do.
El Paso del Norte, (Salazar's observatory)	31 44 15.7	…	…	106 29 05.4	1852	Signal flashes simultaneously observed at Frontera.	†Long. by W. H. Emory, lat. by Señor Salazar.
El Paso del Norte, (cathedral)	31 44 15.7	…	…	106 29 00.0	1852	do	Do. do.
San Elceario, (observatory)	31 35 12.62	1851	Transits over prime vertical.	106 16 15.0	1852	Moon culminations.	Lieut. Smith.
San Elceario, (cathedral)	31 35 02.3	1851	do.	106 16 13.8	1852	do	W. H. Emory.
Mouth of Cañon, (Major Emory's observatory.)	31 02 26.15	[illegible]	Zenith telescope	105 37 15.0	1852	Flashes of gunpowder simultaneously obs. at San Elceario.	Do. do.

*Since this point was established, the corresponding observations at Greenwich observatory have been furnished in manuscript by Prof. Airy, Astronomer Royal; and the result deduced therefrom is 7*h*. 23*m*. 35*s*.3, showing a difference of 11*s*.2 from the adopted longitude.

† Moon culminations also observed by Salazar, and resulting longitude found to correspond.

W. H. E.

E.—*Table of Latitudes and Longitudes*—Continued.

Station.	Latitude North.	DETERMINED.		Longitude West of Greenwich.	DETERMINED.		Observer.
		When.	How.		When.	How.	
	° ′ ″			° ′ ″			
Near mouth of Cañon, where San Antonio road strikes the Rio Bravo.	31 02 25.4	1852	Survey from astronomical station.	105 37 23.7	1852	Survey from astronomical station.	W. H. Emory.
Presidio del Norte, (Major Emory's observatory, opposite.)	29 34 07.13	1852	Zenith telescope...	104 24 45.3	[illegible]	Moon's culminat'ns.	Do.
Presidio del Norte, (cathedral)...........	29 33 53.12	1852	.......do...........	104 26 27.7	1852	Triangulation from observatory.	Salazar.
Camp No. 1, (Lieut. Michler's, Station No. 91, survey of Rio Bravo del Norte.)	29 47 12.9	1853	Sextant............	102 17 21.0	1853	Survey............	Lieut. Michler.
Camp No. 3, Station No. 130............	29 48 41.2	1853	.......do...........	102 04 19.0	1853	....do.............	Do.
Camp No. 4, Station No. 171............	29 48 36.8	1853	.......do...........	101 51 52.0	1853	....do.............	Do.
Camp No. 5, Station No. 211............	29 46 18.3	1853	.......do...........	101 41 05.0	1853	....do.............	Do.
Camp No. 6, Station No. 294............	29 45 08.6	1853	.......do...........	101 26 29.0	1853	....do.............	Do.
Camp No. 7, Station No. 325, opposite mouth of Rio Pecos.	29 41 45.5	1853	.......do...........	101 19 35.0	1853	....do.............	Do.
Camp No. 12, above Eagle Pass..........	28 43 03.2	1853	......do...........	100 30 24.0	1853	....do.............	Do.
Fort Duncan, (observatory).............	28 42 43.67	1852	.......do...........	100 30 26.7	1852	Moon's culminat'ns.	W. H. Emory's longitude, and Lt. Michler's latitude.
Fort Duncan, (flag-staff)...............	28 42 16.4	1852	.......do...........	100 30 19.3	1852	....do.............	Do. do.
Falls of Presidio de Rio Grande........	28 16 11.5	1853	.......do...........	....	1852	....	Lieut. Michler.
Fort McIntosh, (astronom'l station, near)	27 30 22.75	1852	.......do...........	99 28 47.0	1852	Survey............	W. H. Emory.
Fort McIntosh..........................	27 30 08.0	1852	...... do..........	99 29 07.0	1852	.... do............	Do.
Redmond's Ranch, or Bedville..........	26 52 06.8	1853	...... do..........	99 17 27.0	1853	Sextant...........	Do.
Roma..................................	26 24 20.8	1853	...... do..........	98 59 17.0	1853	.... do............	Do.
Ringgold barracks, (observatory).......	26 22 27.8	1853	Zenith telescope....	98 46 32.85	1853	Moon's culminat'ns.	Do.
Ringgold barracks, (flag-staff of garrison.)	26 22 30.5	1853	...... do..........	98 46 37.93	1853	.... do............	Do.
Edinburgh..............................	26 05 53.9	1853	Sextant...........	98 13 37.5	1853	Sextant........ ...	Do.
Reynosa, Mexico, (church steeple)......	26 05 34.1	1853	Survey............	98 14 22.4	1853	Survey............	Do.
Old Fort Brown.........................	25 53 16.3	1853	Sextant......	97 26 22.5	1853	.... do............	Do.
Observatory near mouth of Rio Bravo....	25 57 21.82	1853	Zenith telescope....	97 07 37.5	1853	Moon's culminat'ns.	Do.
Northern point at mouth of Rio Bravo....	25 57 18.20	[illegible]	...... do..........	97 07 22.5	1853	.... do............	Do.
Mouth of Rio Bravo.....................	25 57 10.0	......	....	97 07 17.0	1853	.... do............	Do.
Camp west of, and near, Fort Inge, Texas.	29 10 18.4	1851	Sextant...........	99 47 12.0	1853	Survey............	Do.
Camp on Leona river, 15,000 feet north of Fort Inge, Texas.	29 12 47.1	1850	...... do..........	....	......	....	Lieut. Whipple.
Fort Inge, Texas.......................	29 10 18.4	1851	...... do..........	99 47 10.0	1853	Survey............	W. H. Emory.
Near Turkey creek......................	29 13 46.0	1850	...... do..........	....	......	....	Lieut. Whipple.
Las Moras..............................	29 18 35.0	1850	...... do..........	....	......	....	Do.
Rio San Pedro, (1st crossing)..........	29 29 21.6	1852	.. ... do..........	100 57 35.0	1852	Survey............	Lieut. Michler.
Devil's Camp...........................	29 57 02.0	1850	...... do..........	....	......	....	Lieut. Whipple.
Devil's River Valley...................	30 03 52.1	1850	...... do..........	....	......	....	Do.
Camp XV, where road leaves San Pedro going to El Paso.	30 10 38.4	1851	...... do..........	....	......	....	W. H. Emory.
Camp Steel.............................	30 23 59.6	1850	...... do..........	101 11 13.2	1850	Sextant...........	Lieut. Whipple.
Howard's Spring........................	30 28 00.5	1850	...... do..........	101 27 15.0	1850	.... do............	Do.
Camp on Rio Pecos......................	30 59 59.5	1850	..... do..........	....	......	....	Do.
Camp where road leaves Rio Pecos, going west.	30 58 48.0	1851	...... do..........	....	......	....	W. H. Emory.
Escondido creek........................	30 52 23.0	1850	...... do..........	....	......	....	Lieut. Whipple.
Camanche Spring........................	30 52 59.5	1850	...... do..........	....	......	....	Do.
Leon Spring............................	30 53 33.1	1850	...... do..........	103 04 13.0	1850	Survey............	Do.
Prairie Camp...........................	30 49 01.7	1850	...... do..........	....	......	....	Do.
Limpia Camp............................	30 44 51.0	1850	...... do..........	....	......	....	Do.
Limpia, (Vallecito)....................	30 41 26.0	1850	...... do..........	....	......	....	Do.
Alamo Grove............................	30 36 30.6	1850	...... do..........	....	......	....	Do.
Camp on the Tascite....................	[illegible]	1852	...... do..........	104 14 48.0	1852	Sextant...........	W. H. Emory.
Snow Camp..............................	30 36 28.7	1850	...... do..........	....	......	....	Lieut. Whipple.
Dead Man's Hole........................	30 40 49.9	1850	...... do..........	104 22 05.5	1850	Sextant...........	Do.
Well's Camp............................	30 53 17.5	1850	...... do..........	....	......	....	Do.
Eagle Spring...........................	30 59 58.5	1850	...... do..........	....	......	....	Do.
Dry Camp...............................	31 03 58.2	1850	...... do..........	....	......	....	Do.

CHAPTER IX.

METEOROLOGY.

Sir: The meteorological notes taken during the march from San Antonio to El Paso, during the latter part of 1850, though sufficiently interesting of themselves, do not furnish data for averaging the temperature, &c., and therefore cannot be recorded in the same form as that adopted for the publication of observations taken at a fixed observatory.

The principal and most interesting portion of the observations is the result deduced and embodied in the barometrical profile of the road already prepared.

The record of both wet and dry bulb thermometers was carefully kept. The highest degree noted was on the 23d October, 1850, at 3 P. M., eighty-four degrees; while the lowest was at sunrise of the 6th of December, of the same year, when the mercury fell to 1°.5 Fahrenheit. These results are interesting only so far as noting these two extreme points. From the nature of the marches made, it was impossible to note with any regularity the daily change in any of the instruments.

The chief phenomena noted are those of a local character. The effect of the different ranges of mountains and the long succession of arid plains upon the condition of the atmosphere is shown by the markings of the hygrometer. In passing from the shores of the Gulf to San Pedro, or Devil's river, but little change takes place—the same succession of dews, the usual quantity of rain, and, indeed, all the characteristics of a climate enjoying its proper share of humidity are met with. The clouds of the usual forms, cirrus and nimbus, float about, and nothing as yet gives notice that we are approaching a different country. One single day's march, and this is perceptibly changed. The summit of the valley of the San Pedro reached, the hygrometrical condition of the atmosphere is altered at once, the appearance of the vegetation is different, and the whole face of the country shows the effect of the diminution of moisture so accurately and so immediately pointed out by the hygrometer. We cannot speak with certainty of the effect of the change on any of the instruments except the hygrometer; but that the barometer is seriously affected there can be no doubt, though to what extent can only be told by more perfect unhurried examinations. The observations point out the existence of such a change; they show, too, the line of country at which the change commences; and it only remains to fix the exact amount of correction to be used, to make the barometer as useful in these regions as in those countries bordering on the seacoast, or where the great lack of humidity is not so sensibly felt.

During the march, there was experienced a norther of the most perfect character; this occurred on the 4th and 6th of December, and it was at the latter date that the lowest temperature was noted.

The norther commenced at 4 P. M. of the 4th December, and was preceded by no change by which its approach could be predicted. A calm, pleasant day, with the thermometer ranging

from 40° to 70° Fahrenheit, was ended by a sudden rising of the wind from the southwest; this changed to the northeast, and blew heavily from that quarter for more than twenty-four hours; during this time the thermometer fell to 1°.5 Fahrenheit, and snow fell to the depth of one inch and a half.

The cold weather lasted for about three days, and a most delightful calm succeeded the severest norther noted in the record. A few days after this, the regular observations were taken up and continued at San Elceario and Frontera; those results, reduced for one year to the form adopted for publication, will be more interesting than these under discussion can be made.

The appearance of the clouds varies so little that it forms no meteorological feature of sufficient importance to be accurately noted. The changes, as might be expected, are from the forms in which a certain degree of moisture necessarily enters to those in which the appearance is that of a fleecy mass of cotton without shape. These last are so far removed from the earth's surface as to be almost entirely out of the influence of the currents of wind indicated by the weather-vanes. Their formation seems gradual, and the increase in size is apparently due to a decrease in the distance. They came and vanished sometimes from the same spot in the heavens; and for weeks together scarcely one "direction" due to the course of the wind could be noted. In watching them carefully, their volume would seem to be lessened or increased, and yet the parts detached could not be seen to float away, nor was there any approach of additional vapor to be seen by which the size of the cloud could be increased.

The character of the winds, with their force and direction, was carefully noted; in particular their effect on the barometer was the subject of repeated observations. The results of these observations are more accurately noted in another place. And though the effect produced was first noticed on the march, yet subsequent observations at the fixed observatory only served to strengthen and confirm the opinion which was at that time advanced as to the effect of any change from east to west, or *vice versa*, on the barometrical column.

The records of the observations taken at the fixed observatories at San Elceario and Frontera are given fully for one year. These observations were made in the immediate valley of the Rio Grande, and show the changes in the different instruments noted. With regard to the value to be placed on the observations for humidity, it should be observed that the time embraced in the record was one of great freedom from moisture, both at the points observed and at situations on the river far above the observatory. The river during the summer of 1851* was nearly dry in several places in our immediate vicinity, a slight current only marking its progress near Frontera, while its bed served as the best road thence to El Paso.

The chart prepared to accompany this report shows at a glance the most important results deduced from our observations.

The results given in the separate columns of the tabulated forms are deduced from six daily observations, viz: at sunrise, 9 A. M., noon, 3 P. M., sunset, and 8 P. M. During the long days of summer this last hour was changed to 9 P. M., thus making the interval between sunset and the time of the last evening observation more nearly equal in the different seasons.

The columns in which are noted the daily means for thermometer and dew-point observations

* The year 1851 was notoriously a dry year in all the northern States of Mexico, and so far the selection of that year is unfortunate as affording a measure of the average rain, but it happened to be the only year when a single observer was stationary for any length of time at the same place.

W. H. E.

will, of course, present different records from those which would have been shown had the results merely been deduced from the two daily extremes of heat and cold, or the dew-points calculated from those observations only.

In addition to all these observations, the 21st day of each month, as the regular meteorological term-day, was carefully noted by the record of observations for each hour of the twenty-four.

The remainder of the meteorological data serves in a great measure merely for the calculation of the elevation of points on the line of survey or travel. These results will be found embodied in the different profiles of the country over which the line passed.

The observations of 1855, by a careful comparison with others of the same character, taken simultaneously at different places, have enabled me to establish the height of the initial point of the boundary on the Rio Grande in a manner that must be more satisfactory than any yet adopted.

This elevation varies slightly from that of El Paso.

In the computation for elevation I have used the French formula of Delcros, and have employed some other corrections consequent upon the value of horary variation, founded on the observations for that quantity taken at San Elceario. In most instances, however, the points of observation were too remote from the fixed observatory for the horary correction to be of any great value. In these the usual corrections for temperature, &c., only were used.

The effect of the direction and force of the wind on the mercury of the barometer has been referred to above, and I mention it here only to state that my observations on this subject were sufficient to assure me of the great necessity of noticing these values in connexion with the barometer more particularly when observations are being made for altitude. The exact value of the quantity I have not ascertained, but that it exists I am confident; and I trust that future and more prolonged observations will fix the value in a manner sufficiently accurate for its use as a correction in barometrical computations.

All of which is respectfully submitted by your obedient servant,

MARINE T. W. CHANDLER,

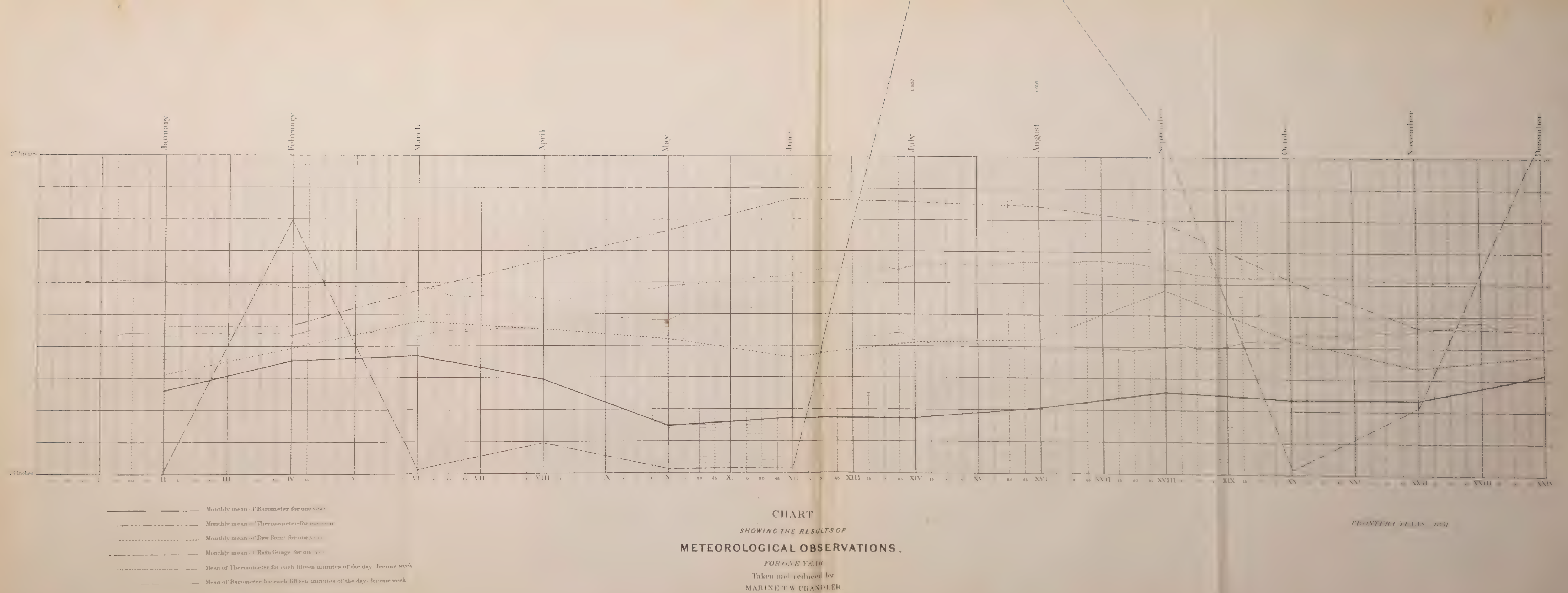
Assistant in charge of Meteorological Department.

Major William H. Emory, 1*st Cavalry U. S. A.*,

Commissioner United States and Mexican Boundary Survey.

Note.—Of the immense mass of materials collected, showing the meteorological character of the country adjacent to the boundary line, I have deemed it proper to produce here only a short abstract from the tables. Those who may desire further information can obtain it by reference to the records filed in the Department of the Interior.

W. H. E.



CHART

SHOWING THE RESULTS OF

METEOROLOGICAL OBSERVATIONS.

FOR ONE YEAR

Taken and reduced by

MARINE T. W. CHANDLER,

under the direction of Major W. H. EMORY.

FRONTERA TEXAS 1851

Abstract of results from meteorological records.

Date.	Station.	Mean height of barometer.	Mean height of thermometer.	Dew point.	Greatest heat.	Least heat.	Rain, inches.
1851.							
January	San Elceario	26.26	46.3	31	67	47	.004
February	do	26.354	46.29	39.19	....	....	0.795
March	do	26.370	57.7	47.9	81	22.5	0.015
April	do	26.295	67	45.2	87.5	40.5	0.092
May	Frontera	26.146	76.4	42.0	95	50.5	0.013
June	do	26.173	86.8	36.6	103	59	0.016
July	do	26.174	85.9	41.2	99	71	1.537
August	do	26.206	84.1	42.1	....	....	1.613
September	do	26.254	79.13	57.89	92	65	1.052
October	do	26.233	67.6	42.1	87	47	0.013
November	do	26.233	50.8	36.6	73	25	0.211
December	do	26.317	45.5	37.7	63	27	1.255
1854.							
December	Near junction of Gila and Colorado	29.979	59.8	....	72	48.5	....
1855.							
February	do do	29.937	68	....	82	53	....

BAROMETRIC HEIGHTS.

	Feet.
Fort Brown	165. 5
Ringgold Barracks	521. 6
Edinburgh	422. 3
Fort McIntosh	806. 4
Eagle Pass or Fort Duncan	1461. 0
San Antonio	578. 7
Castroville	671. 9
Quihi	855. 6
Rio Seco	936. 7
Comanche creek	923. 6
Camp near Fort Inge	910. 8
Camp near Nueces	931. 7
Elm creek	1093. 5
Zoqueté creek	983. 0
San Felipe	8[illegible]. 9
Painted Caves	952. 4
San Pedro or Devil's river	1810. 0
Second crossing San Pedro	1843. 2
Head of San Pedro	1680. 5
Howard's spring	2053. 5
Live Oak creek	2083. 4
Pecos	2026. 9
Escondido spring	2806. 1
Leon spring	3098. 2
Limpia	4004. 3
Head of Limpia	4688. 4
Eagle spring	4535. 5
Station near Presidio del Norte	2779. 0
Rio Bravo (where road from San Antonio strikes it)	3484. 0
San Elceario	3607. 3
Initial point on Rio Bravo, parallel 31° 47′ N	3684. 3
Frontera	3796. 3
Neides' spring	4309. 8
Cook's spring	4777. 0
Santa Rita del Cobre	6106. 4
Ojo de Vaca	4988. 6
Carrizalillo	4454. 7
Espia	4027. 5
Ojo de Inez or de Gavilan	5293. 4
Ojo del Perro	4691. 7
Alamo Hueco	4650.
Ojo del Picacho	4694. 3
Salt Lake, (parallel 32° 22′ N)	3994. 2
Salt Lake spring, (playa de los Pimos)	4193. 7
Quercus Cañon	4169. 7
Camp on Gila, near Mount Graham	2976. 1
Summit of San Luis mountain	5818. 9
Ojo de San Luis	5044. 0
Guadalupe Cañon	4447. 8
San Bernardino	3676. 8
Agua Prieta	4017. 0
Spring at head of Rio San Pedro, 1st branch east	4383. 8
Rio San Pedro, near parallel 32° 22′	3717. 6
Summit of pass to and near Santa Cruz	5469. 5
Santa Cruz	4498. 3
Los Nogales	3835. 7
Junction of Gila and Colorado	275. 0
New Initial Point on Colorado	156. 3

MAGNETIC OBSERVATIONS.

Magnetic observations on the boundary line between the United States and Mexico, made in 1855, *under the direction of Major W. H. Emory, United States commissioner under the treaty of* 1853; *and general discussion of the magnetic observations made in connexion with the Mexican Boundary Surveys.*

RECOMPUTED BY J. E. HILGARD, UNITED STATES COAST SURVEY.

I. *Magnetic observations in* 1855.

Observations of declination, dip, and absolute horizontal intensity were made at eight stations, being those at which astronomical observations were made in determining the boundary between the United States and Mexico, under the treaty of 1853. The magnetic observations were intrusted to Mr. Marine T. W. Chandler, who succeeded in obtaining very complete determinations, as the subjoined abstracts show.

The *declination* was obtained by referring the direction of the needle to the astronomical meridian carefully determined for the survey of the line. The needle of a goniometer (by Young) was found to show a fair mean of five good needles of different lengths, and was therefore relied on at subsequent stations. The results are given in the general table below.

Observations of *inclination* were made with a ten-inch dip-circle (by Gambey) of superior construction. Two needles were used at each of the stations; and at three of them, viz: Carrizalillo, Espia, and Los Nogales, the poles were repeatedly reversed, so as to obtain the corrections to be applied when no reversal of poles was made. These corrections are + 12′ for needle No. 1, and — 15′ for No. 2, in the position of the poles called direct, and have been so applied in the following abstract of results:

Station.	Needle No. 1.		Needle No. 2.		Remarks.
	Dip.	No. of sets.	Dip.	No. of sets.	
	° ′		° ′		
Initial Point	58 39	3	58 19	3	
Carrizalillo	58 31	3	58 13	3	Poles reversed in each set.
Espia	57 50	1	57 50	2	" " " "
Ojo del Perro	57 28	2	57 5	2	
San Luis Springs	57 37	1	57 21	1	
San Bernardino	57 19	4	56 58	4	
Santa Cruz river	57 28	2	57 17	2	
Los Nogales	57 13	1	57 1	1	Poles reversed in each set.

The difference of about 16′ between the results by the two needles is too large to admit of the mean being taken. An examination of the pivots having shown some corrosion on a pivot of No. 2, the probability is that the results by No. 1 are to be preferred, especially as the observations with that needle show a greater consistency among themselves. The results by No. 1 are therefore adopted in the general table.

Observations for horizontal intensity were made with a unifilar magnetometer by Jones. The deflections were measured on a nine-inch circle, according to Lamont's method, in which the two magnets remain at right angles. In the vibration experiments, the time of 400 vibrations is usually observed, of which six values are obtained in each set, in the usual way. Experiments to determine the moment of inertia of the magnet and its attachments were made repeatedly by vibrating it loaded with a brass ring, marked No. 11, of which the outside diameter is 2.899 inches, the inside diameter 2.462 inches, and the weight 719.90 grains: hence its moment of inertia, $K_r = 9.04$, expressed in feet and grains. The magnet used, marked X 7, is of the usual form, being a hollow cylinder of 0.3 inch in diameter, and 3.66 inches in length, and carrying a mirror. Its temperature coefficient was determined at Washington city, in February, 1856, by vibrations at temperature near 30° and 70°, and was ascertained

$$q = 0.0003.$$

The following is an abstract of the observations: to which is to be added, that, in the experiments without the inertia ring, the effect of 90° of torsion was 7'.5; in those with the ring, 15'.

Abstract of observations for horizontal intensity.

Stations.	Vibrations. Without ring. T Time of 1 vibr.	Vibrations. Without ring. Temperature.	Vibrations. With ring. T_r Time of 1 vibr.	Vibrations. With ring. Temperature.	Deflections. $r = 1.3$ feet. u	Deflections. $r = 1.3$ feet. Temperature.	Date.
	s.	°	s.	°	° '	°	
Initial Point	3.795	74.5	7.946	69.5	2 39.6	62	1855.
	3.796	59	7.935	63	35.7	53.5	
					30.8	42	
Mean	3.795	67	7.941	66	2 35.4	52	January 4.
Carrizalillo	3.917	70	....	....	2 32.2	59	
	3.930	71.5	7.983	76	2 31	67.5	
	3.936	83	....	....	2 29.9	64.5	
Mean	3.928	75	7.983	76	2 30.7	64	March 1.
Espia	3.779	63	7.920	70	....	....	March 22.
Ojo del Perro	3.794	63	....	....	....	....	April 3.
San Luis Springs	3.751	61	....	....	2 38.0	64.5	
	3.757	73	....	....	2 30.0	66.5	
					2 27.8	65	
Mean	3.754	67	....	....	2 30.0	65	April 19.
San Bernardino	3.776	78.5					
	3.778	88.5					
	3.764	51.					
Mean	3.773	51	....	....	....	....	April 25.
Santa Cruz River	3.798	72					
	3.804	74					
Mean	3.801	73	....	....	....	....	May 24.
Los Nogales	3.805	94	7.965	80	2 26.5	81.5	
					25.2	59	
Mean	....	....	....	....	2 25.55	82	June 26.

From the preceding data we first deduce the moment of inertia, K, of the magnet and its attachments, by the equation $K = K_r \frac{T^2}{T_r^2 - T^2}$, where T_r and T are the terms of one vibration with and without the inertia ring, corrected for torsion, and reduced to the temperature of experiments without the ring, and obtain the following values:

At Initial Point,	$K =$ 2.669
Carrizalillo,	2.680
Espia,	2.659
Los Nogales,	2.668
Mean,	2.669

From the experiments of deflection we next deduce the values of ratio of m, the magnetic moment of the magnet, to X, the horizontal component of the earth's form, by the expression $\frac{m}{X} = \frac{1}{2} r^3 \sin u$, and obtain at

Initial Point,	$\frac{m}{X} =$ 0.0477,	temp. 52°
Carrizalillo,	0.0481,	" 64°
San Luis,	0.0476,	" 65°
Los Nogales,	0.0466,	" 82°

Computing for the same stations the product $m\,X = \frac{\pi^2 K}{T^2}$, where T is corrected for torsion, and reduced to the temperature of the corresponding deflections, and eliminating X, we get the following values of m.

Station.	Date.	m	Temperature.	m reduced to 66°.
			°	
Initial Point	January 4	0.2959	52	0.2947
Carrizalillo	March 1	0.2951	64	0.2949
San Luis	April 19	0.2982	65	0.2981
Los Nogales	June 16	0.2915	82	0.2929

Although the difference in these values of m may be in a great measure due to errors of observations, rather than to fluctuations in the magnetism of the magnet, still the best results appear to be obtained by using the above values of m for the respective stations, and assuming a uniform rate of change during the intervals.

Computing, lastly, $m\,X$ for each of the stations, and dividing by m determined in the manner indicated and reduced to the temperature of the vibrations, we obtain the values of X given in the subjoined table, which exhibits collectively the results obtained.

General table of results.

Station.	Latitude.	Longitude.	Declination east.	Dip.	Horizontal intensity.	Total intensity.
	° ′	° ′	° ′	° ′		
Initial Point	31 47	106 28	11 55	58 39	6.202	11.92
Carrizalillo	31 51	107 56	12 2	58 31	6.125	11.73
Espia	31 21	107 56	12 5	57 59	6 242	11.77
Ojo del Perro	31 21	108 20	11 58	57 28	6.156	11.45
San Luis Springs	31 20	108 48	11 45	57 37	6.265	11.70
San Bernardino	31 20	109 14	11 45	57 19	6.252	11.58
Santa Cruz River	31 18	110 31	12 13	57 28	6.169	11.47
Los Nogales	31 21	110 51	11 45	57 13	6.262	11.56

II. *Discussion of lines of equal magnetic declination, dip, and horizontal intensity.*

In this discussion, the observations made in previous years in connexion with the Mexican boundary surveys, and published in the fifth volume, new series, of the Memoirs of the Academy, have been combined with those communicated in the present paper. Observations made under the direction of Professor A. D. Bache, Superintendent of the Coast Survey, at stations Dollar Point, East Base, and Jupiter, near Galveston, Texas, and near San Diego, Monterey, and San Francisco, and affording important co-ordinates for the curvature of the lines, have also been introduced; likewise, an observation of the declination at the Great Salt Lake, by Captain Howard Stansbury, U. S. Topographical Engineers, published in his report of the survey of that region.

The method employed in determining the lines of equal declination and dip was partly graphical and partly analytical, being the same pursued by Professor Bache and Mr. J. E. Hilgard in their discussion of the Coast Survey magnetic observations.—(Coast Survey Report for 1855, Appendix, p. 47.) The stations were projected on a map, and their positions referred to a right line graphically assumed as axis of co-ordinates, the origin being chosen about the mean position of the stations, and the direction so as nearly to divide the positive and negative ordinates equally.

The co-ordinates being read off on any convenient linear scale, conditional equations are formed for each station or group of stations, and the whole scheme is solved by the method of least squares. The conditional equations representing an interpolation by second differences are of the form,

$$V = V_0 + v + x X + y Y + z X Y + p X^2 + q y^2,$$

when V is the observed declination (or dip);

V_0, the assumed declination at the origin; v, the correction to be applied;

X and Y, co-ordinates of position.

x, y, z, p, q, coefficients to be determined.

The solution of a considerable number of such equations involves a great deal of labor, which the results amply repay, however. The process being well known, there is no occasion to give the steps of the calculations in this place. After determining the coefficients, the co-ordinates of points in the lines sought were computed, the lines projected on the map, and the latitudes and longitudes of points read off and tabulated.

In the absence of any data to determine the secular changes, the results are doubtless liable to an uncertainty from that source. We know, however, that the changes are small, and, for the limited period over which the observations extend, they may be considered as merged in the local errors, and the average date of 1852 as belonging to the resulting lines on the map.

The following tables give a general *résumé* of the observations, and the corresponding values in the computed system; also the residuals, the distribution of which is the best evidence of the successful representation of the general facts involved.

The geographical position of points in the lines of equal declination and dip—isogonic and isoclinal lines—are also given in tables from which they may be readily projected in any map.

Observations of Declinations.

No.	Station.	Latitude.	Longitude.	Date.	Declination east, observed.	Declination east, computed.	Residual, computed — obs.
		° ′	° ′		° ′	° ′	′
1	Dollar Point	29 26	94 53	1848	8 57	9 03	+ 06
2	East Base	29 13	94 55	1853	9 05	9 02	— 03
3	Jupiter	28 55	95 20	1853	9 09	9 10	+ 01
4	Rio Grande, mouth	25 57	97 07	1853	9 00	8 56	— 04
5	Ringgold Barracks	26 23	98 43	1853	9 15	9 18	+ 03
6	Fort McIntosh	27 30	100 05	1852	10 00	9 46	— 04
7	Eagle Pass	28 42	100 30	1852	10 01	10 07	+ 06
8	Presidio del Norte	29 34	104 25	[illegible]	10 16	10 53	+ 37
9	Mouth of Cañon	31 02	105 37	1852	12 01	11 28	— 33
10	Emory's Initial Point	31 47	106 28	1855	11 55	11 48	— 07
11	Frontera	31 49	106 29	[illegible]	12 24	11 49	+ 25
12	Doña Ana	32 22	106 45	1851	12 07	12 02	— 05
13	Carrizalillo	31 51	107 56	1855	12 02	11 58	— 04
14	Espia	31 21	107 56	1855	12 05	11 48	— 17
15	Copper Mines	32 48	108 04	1851	11 22	12 18	+ 56
16	Ojo del Perro	31 21	108 20	1855	11 59	11 50	— 09
17	San Luis Springs	31 20	108 48	1855	11 45	11 52	+ 07
18	San Bernardino	31 20	109 14	1855	11 45	11 53	+ 08
19	Santa Cruz River	31 18	110 31	1855	11 45	11 58	+ 13
20	Los Nogales	31 21	110 51	1855	12 13	12 00	— 13
21	San Pedro	32 59	110 40	1851	12 25	12 37	+ 12
22	Pimos Villages	33 07	111 44	1851	12 52	12 46	— 06
23	Gila Junction	32 43	114 53	1851	12 50	12 45	— 05
24	San Isabel	33 09	116 38	1852	12 34	12 55	+ 21
25	Camp Riley	32 36	117 05	1849	12 57	12 44	— 13
26	San Diego	32 42	117 12	1849	13 15	12 47	— 28
27	San Diego C. S	32 41	117 13	1851	12 29	12 48	+ 19
28	Monterey	36 38	121 54	1851	14 58	14 54	— 04
29	San Francisco	37 48	122 27	1852	15 30	15 34	+ 04
30	Salt Lake City	40 46	112 08	1850	15 34	15 34	00

Isogonic Lines.

[redacted]

Longit'de.	9°	10°	11°	12°	13°	14°	15°	Declination east.
°	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
95	28 50							Latitude.
96	27 28							
97	26 23							
98	25 34	30 17						
99	24 57	29 18						
100		28 32						
101		27 54						
102		27 27	31 12					
103		27 4	30 35					
104			30 7					
105			29 45	[redacted] 8				
106			29 27	32 36				
107			29 14	32 13				
108			29 4	31 54	34 54			
109				31 39	34 29			
110				31 28	34 [illegible]			
111				31 20	33 54			
112				31 14	33 43			
113				31 [redacted]	33 33	36 2		
114					33 24	35 47		
115					33 17	35 35	[redacted] 3	
116					33 14	35 25	[redacted] 46	
117					33 12	35 17	[redacted] 31	
118						35 10	[redacted] 19	
119						35 5	[redacted] 9	
120						35 2	[redacted] 1	
121						35 0	36 54	
122						34 58	[redacted] 48	
123							36 44	
124							[redacted] 41	

Observations of Dip.

No.	Station.	Latitude.	Longitude.	Date.	Dip observed.	Dip computed.	Residual, comp. obs.
1	Dollar Point	29° 26′	94° 53′	1848	57° 58′	58° 00′	+ 2′
2	East Base	29 13	94 55	1853	57 42	57 45	+ 3
3	Jupiter	28 55	95 20	1853	57 12	57 07	− 5
4	Rio Grande, mouth	25 57	97 07	1853	52 23	52 14	− 9
5	Ringgold Barracks	26 23	98 43	1853	52 27	52 35	+ 8
6	Fort McIntosh	27 30	100 05	1852	54 07	53 58	− 9
7	Fort Duncan	28 42	100 30	1852	55 31	55 35	+ 4
8	Presidio del Norte	29 34	104 25	1852	55 41	55 59	+ 18
9	Mouth of Cañon	31 02	105 37	1852	57 38	57 45	+ 7
10	San Elceario	31 35	106 16	1852	58 57	58 17	− 30
11	Frontera	31 48	106 33	1852	59 05	58 32	− 33
12	Doña Ana	32 22	106 47	1851	59 06	59 08	+ 2
13	IX	22 22	107 24	1851	59 09	59 00	− 9
14	Copper Mines	32 47	108 04	1851	59 17	59 23	+ 6
15	Emory's Initial Point	31 47	106 28	1855	58 39	58 30	− 9
16	Carrizalillo	31 51	107 56	1855	58 31	58 23	− 8
17	Espia	31 21	107 56	1855	57 39	57 41	− 18
18	Ojo del Perre	31 21	108 20	1855	57 28	57 40	+ 12
19	San Luis	31 20	108 48	1855	57 37	57 36	− 1
20	San Bernardino	31 20	109 14	1855	57 19	57 30	+ 11
21	Santa Cruz River	[illegible] 18	110 31	1855	57 28	57 21	− 7
22	Los Nogales	31 21	110 51	1855	57 13	57 21	+ 8
23	Ojo de Inez, or Gavilan	32 45	108 14	1851	59 18	59 22	+ 5
24	Station 1 (along the Gila)	32 50	109 34	1851	59 19	59 12	− 7
25	2	32 50	109 37	1851	59 12	59 12	0
26	3	32 53	109 44	1851	59 12	59 15	+ 3
27	4	32 57	109 49	1851	59 20	59 18	− 2
28	5	33 04	109 55	1851	59 27	59 25	− 2
29	6	33 06	110 00	1851	59 38	59 30	− 8
30	7	33 10	110 03	1851	59 42	59 33	− 9
31	8	33 12	110 10	1851	59 37	59 35	− 2
32	9	33 13	110 19	1851	59 45	59 35	− 10
33	10	33 12	110 19	1851	59 34	59 30	− 4
34	12	33 09	110 26	1851	59 37	59 28	− 9
35	13	33 09	110 28	1851	58 58	59 26	+ 28
36	15	33 09	110 31	1851	59 28	59 25	− 3
37	17	33 12	110 42	1851	59 23	59 28	+ 5
38	19	33 05	110 35	1851	59 5	59 19	+ 14
39	20	32 59	110 40	1851	59 11	59 13	+ 2
40	21	33 03	110 46	1851	58 59	59 16	+ 17
41	22	33 05	110 50	1851	59 13	59 18	+ 5
42	23	33 07	110 55	1851	59 23	59 20	− 3
43	24	33 06	111 02	1851	59 20	59 18	− 2
44	26	33 04	111 11	1851	59 25	59 14	− 11
45	27	33 03	111 16	1851	59 20	59 12	− 8
46	28	33 01	111 23	1851	59 16	59 10	− 6
47	29	33 04	111 34	1851	59 06	59 10	+ 4
48	30	33 08	111 44	1851	59 06	59 14	+ 8
49	31	33 10	111 54	1851	59 28	59 16	− 12
50	32	33 09	111 57	1851	59 22	59 16	− 6
51	38	33 00	112 39	1851	58 53	58 57	+ 4
52	39	32 59	112 43	1851	58 49	58 56	+ 7
53	40	33 02	112 55	1851	59 16	58 59	− 17
54	42	32 58	113 11	1851	59 17	58 52	− 25
55	43	32 49	113 33	1851	58 43	58 39	− 4
56	44	32 44	113 50	1851	58 30	58 30	0
57	45	32 41	114 05	1851	58 25	58 26	+ 1
58	Gila Junction	32 43	114 33	1851	58 30	58 28	− 2
59	New River	32 42	115 25	1849	58 19	58 20	+ 1
60	Santa Isabella	33 08	116 41	1849	58 48	58 44	− 4
61	Santa Maria	33 02	116 51	1849	58 42	58 37	− 5
62	San Diego	32 42	117 08	1849	57 33	58 14	+ 41
63	San Diego C. S.	32 41	117 13	1851	57 38	58 12	+ 34
64	San Francisco	37 46	122 27	1852	62 32	62 40	+ 8
65	Sacramento	38 34	121 17	1852	64 03	63 37	− 26

Isoclinal Lines.

GEOGRAPHICAL POSITIONS OF POINTS.

Long.	52°	53°	54°	55°	56°	57°	58°	59°	60°	61°	62°	63°	Dip.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
95	25 30	26 09	26 48	27 27	28 07	28 47	29 26	....	....	....	....	....	
96	25 38	26 18	26 57	27 37	28 17	28 57	29 37	....	....	....	....	....	
97	25 46	26 26	27 06	27 47	28 27	29 08	29 49	....	....	....	....	....	
98	25 34	26 35	27 15	27 56	28 37	29 18	30 00	....	....	....	....	....	
99	26 02	26 43	27 24	28 05	28 47	29 [illegible]	30 11	....	....	....	....	....	
100	26 09	26 51	27 33	28 14	28 56	[illegible]	30 21	....	....	....	....	....	
101	....	26 59	27 41	28 22	29 05	29 48	30 22	....	....	....	....	....	
102	....	....	27 49	28 31	29 14	29 57	30 42	....	....	....	....	....	
103	....	....	....	28 40	29 23	30 06	30 52	....	....	....	....	....	
104	....	....	....	....	29 32	30 16	31 02	....	....	....	....	....	
105	....	....	....	....	29 40	30 24	31 11	31 59	32 49	....	....	....	
106	....	....	....	....	29 47	30 32	31 20	32 09	32 58	....	....	....	
107	....	....	....	....	29 54	30 39	31 28	32 18	33 07	....	....	....	
108	....	....	....	....	30 00	[illegible]	31 36	32 27	33 16	....	....	....	
109	....	....	....	....	29 05	30 [illegible]	31 43	32 35	33 25	....	....	....	Latitude
110	....	....	....	....	30 10	30 [illegible]	31 50	32 43	33 33	....	....	....	
111	....	....	....	....	....	31 05	31 57	32 50	33 49	....	....	....	
112	....	....	....	....	....	31 11	32 04	32 57	33 49	....	....	....	
113	....	....	....	....	....	31 17	32 11	33 04	33 57	....	....	....	
114	....	....	....	....	....	31 22	32 16	33 10	34 04	....	....	....	
115	....	....	....	....	....	31 26	32 21	33 16	34 11	35 07	....	....	
116	....	....	....	....	....	31 31	32 26	33 23	34 18	35 15	....	....	
117	....	....	....	....	....	31 35	32 31	33 28	34 24	35 22	36 19	....	
118	....	....	....	....	....	31 [illegible]	32 26	33 33	34 30	35 29	36 27	....	
119	....	....	....	....	....	....	....	....	....	35 36	36 35	37 35	
120	....	....	....	....	....	....	....	....	....	....	36 42	37 45	
121	....	....	....	....	....	....	....	....	....	....	36 49	37 54	
122	....	....	....	....	....	....	....	....	....	....	....	38 02	
123	....	....	....	....	....	....	....	....	....	....	....	38 11	

Horizontal intensity.—Combining the eight stations of 1855 among themselves, we obtain as a mean result, in latitude 31° 27′, longitude 108° 45′, $X = 6.21$, with a probable error of ± 0.01; also an increase of $+ 0.10$ in going south 30′.7 or east 506′, and the direction of the line of equal horizontal intensity N. 87½° E.

It may be observed, that this rate of change in going south is evidently too large, for according to the decrease of dip it would require a southing of 42′ to cause an increase of the horizontal force of $+ 0.10$, if the total force was constant; but as the latter also decreases in going south, the actual rate of change of horizontal force is probably only half of that above obtained. Moreover, when we consider that the same value of X is found on the coast of Mississippi, between New Orleans and Mobile, we see that the small increase in going east should be decrease of similar amount, and that the direction of the line should be about N. 94° E. The distribution of stations is such that these discrepancies in the rate of change are quite within the probable errors of observation and station errors; nor is the value of the mean result affected thereby, which forms a valuable datum in absolute measure, in an almost inaccessible region of the globe.

In order to compare this measure of force with that previously obtained on the northern line by observations with a Fox apparatus, and expressed in the arbitrary scale, we may have recourse to the observations of Captain Lefroy at Toronto, which gives the total force in British

units = 13.86 at the time that it is found 1.836 in the arbitrary scale. Applying the same ratio to our mean total intensity, 11.65, we find 1.543, and we have the following comparison:

Latitude.	Longitude.	Total intensity.
° ′	° ′	
31 27	108 45	1.543
32 43	108 30	1.580

the latter from three stations in 1851; exhibiting a closer correspondence than might be expected from the circuitous comparison involved.

— — Lines of equal declination
.. Line of equal dip
- - - Line of equal horizontal force

United States & Mexican Boundary Survey.

PART II.

GEOLOGICAL REPORTS

BY

DOCTOR C. C. PARRY AND ASSISTANT ARTHUR SCHOTT.

NOTES BY W. H. EMORY.

PALÆONTOLOGY AND GEOLOGY OF THE BOUNDARY,

BY

JAMES HALL, OF ALBANY, NEW YORK.

DESCRIPTION OF CRETACEOUS AND TERTIARY FOSSILS,

BY

T. A. CONRAD, ESQ.

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CHAPTER II.

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NOTE.—I think it proper to state that I do not concur with Mr. Schott in his conclusion on page 96, where he says: "From this we have the proof of a former immediate connexion in these latitudes between the two oceans of our globe."

In the original proof this conclusion was erased, but by some accident was afterwards inserted. W. H. E.

ERRATA.

On page 91, line 41, for "nearly" read near.

CHAPTER I.

GENERAL GEOLOGICAL FEATURES OF THE COUNTRY.

WASHINGTON, D. C., *April* 1, 1854.

Colonel W. H. EMORY, *United States Commissioner:*

SIR: In completion of the duties assigned me as botanist and geologist to the United States boundary commission, I present the following:

I. GENERAL PHYSICAL AND GEOLOGICAL FEATURES OF THE COUNTRY.

The general features of the Mexican Gulf Coast, in connexion with the United States and Mexican boundary line, present a marked contrast with those observed on the opposite Pacific coast. Thus, instead of the high cliffs, abrupt headlands, and general bold and rugged outline exhibited on the Californian coast, the Texan shore-line, throughout its whole extent, presents a uniform, low dead level. Generally, indeed, the main coast is shut in from the open sea by ranges of sand islands formed by the waves of silted sea sand and comminuted shells. Inside of this line of islands shallow bays spread themselves into the indented coast, and here the numerous rivers flowing from the interior meet the tide-water. The tide range is moreover small, and thus the alternating differences of level do not favor the formation of navigable estuaries by which the main land may be approached. These features, collectively, give to this coast an inaccessible character, and serve to render its navigation both difficult and dangerous.

Its rivers are unapproachable, except by vessels of very light draught; while the inlets to its shallow bays, obstructed by variable sand-bars, present obstacles to navigation, sufficiently proved by the numerous wrecks that strew their beach. Proceeding inland from the line of sandy beach, a gentle slope spreads out in a uniform gradually rising plane, composed of dark rich loam, and covered with luxuriant pasturage. The scenery is rarely relieved of its blank outline by a clump of *live oak* trees surrounding a sunken morass. Farther on, at a variable distance of 10 to 20 miles, the surface of the ground shows gentle swells, still maintaining its fertile character, and displaying here and there groves of *post oak* and other timber. The river bottoms adjoining are occupied with a heavy timber growth, principally of *elm*, (*ulmus crassifolia*,) festooned with *Spanish moss*. The undergrowth comprises a complete maze of shrubbery, matted and tangled together by vines and creepers, and supporting a rank annual growth.

At a distance of 50 to 80 miles from the coast, the ground-swells become more abrupt and form distinct ridges, between which are collected the drainage of the country. Along the course of the numerous streams there is an exposure of the geological substratum, consisting first of loose gravelly strata, which contain erratic pebbles of siliceous or calcareous character; to this

succeed occasional exposures of a coarse-grained sandstone, No. 1. Still farther inland we meet with a form of soft calcareous earthy rock outcropping along the sides of hills, and constituting the first outlayer of that extensive cretaceous formation which characterizes so large a scope of country throughout middle and northwestern Texas.

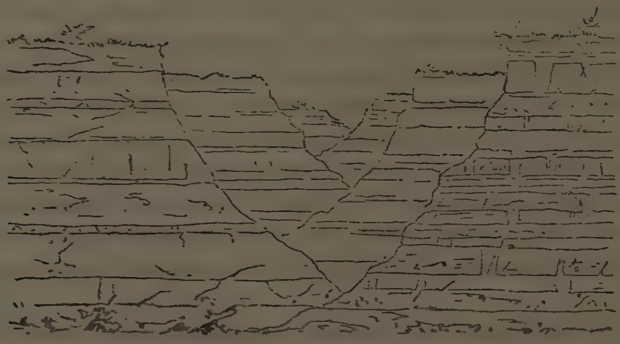
From San Antonio, occupying the first step in the cretaceous series, at an elevation of 600 feet above the Gulf of Mexico, proceeding northerly on the line of the lower road to El Paso, we soon remark a rapid change in the general features of the country. The underlying limestone formation becomes more largely developed, and is less deeply covered with alluvial deposits. The rock stratum is frequently exposed in the beds of streams, which are everywhere thickly strewn with the water-worn pebbles of this formation. The streams here acquire an intermittent character, subject to sudden overflow and recession. Their course, when low, is marked by an irregular series of deep basin ponds connected together only by shallow brooks, or even not at all above ground during dry seasons.

As we proceed, mural exposures of limestone rock become more frequent, and the same formation is met with on summits of the higher table-land. The alluvial tracts along the course of the larger valleys acquire a more arid character of soil, and support a stunted timber growth, in which mezquite makes its appearance. Fossil, fresh water, and land shells are quite abundantly scattered over the lower depressions of these alluvial bottoms.

At the crossing of the Rio Frio, near Fort Inge, occurs the first exposure of igneous rock. It is seen as an isolated knoll of dark-colored trap, showing at this place but slight disturbance of the adjacent cretaceous strata. This formation is thence observed to constitute a broken line, extending in a northwest course, and coming into view at several points along the road at variable distances of 5 to 10 miles.

On approaching the line of the great table-land formation of Northwest Texas, we find near its base the sources of most of the minor streams of this region. These sources frequently exhibit magnificent basin springs, of which that at San Felipe is a noted example.

We have here reached the main development of this extensive cretaceous formation, partially concealed from view towards the coast, as above noticed, by alluvial deposits, but here standing out in bold relief, variously exposed in extensive ridges, bounding, more or less closely, valleys



Character of valley denudations in the cretaceous table-land formation. Upper portion of San Pedro river, Texas.

of denudation, or else stretching in vast upland plateaus, thinly covered with soil, and supporting a close even growth of upland grasses or scanty shrubs.

The true character of this formation may be satisfactorily studied in the course of its principal streams, the Pecos and Devil's river. As exposed along the course of these valleys, the view is bounded by steep mural cliffs, composed of limestone, disposed in nearly horizontal strata. This rock exhibits quite a variable texture, its weathered face showing an uniform gray or bluish tint, while its recent fracture has a much lighter color. Owing to its irregular texture, it frequently exhibits a cavernous structure, displaying in its various exposures all the grotesque features of ruined castles, forts, and dilapidated masonry; examples of which may be seen by reference to numerous sketches.

The river valleys either expand into more or less extensive alluvial basins, or are completely hemmed in by steep mural faces, forming chasms along their course, to which the Spanish term of *cañon* is generally applied. Thus, in following out the course of valleys in this district, we have a series of basins connected by cañons; the relative extent of these distinct topographical features being dependent on the local character of the formation, or the varied influence of previous denuding forces.

The alluvial tracts partake to a great extent in the sterility of the plateaus with which they are connected, seldom showing evidence of fertility, and in a great measure destitute of timber growth.

In the case of the Pecos river, which may be regarded as the main type of streams belonging to this table-land formation, we observe a contracted but constant body of water coursing through alluvial tracts, or clearing its way through rocky cañons.

In the former case, its tortuous course is marked out between deep banks of earth, so that its turbid waters are for the most part invisible till you come directly on its brink. The average width of the stream, during most of the year, is about 50 feet, and 8 feet in depth. Only limited portions of the adjoining valley are subject to that degree of overflow, such as constitutes what is commonly understood as bottom-land. Owing to the steep and crumbling nature of the banks, travellers often experience no small difficulty in watering their animals; the water itself, though highly charged with reddish sediment, is not unpalatable.

In its passage through cañons, this stream, like the Rio Grande, cleaves its way between steep walls of rock; its course during low water being occasionally set off by lines of sandy or pebbly beach, and forming frequent rapids.

All the small intermittent streams of this region are copiously bedded with rounded pebbles, derived from the adjoining limestone formation.

The view from the summit elevations presents not an unbroken table-land, but rather a series of terraces, exhibiting occasionally truncated peaks, and showing a general increasing elevation westward. The mean level is, moreover, marked by depressed valleys, containing dry pebbly beds of streams, and frequently expanding into wide basins. The descent to these valleys is generally abrupt, and is the chief obstacle in the construction of roads, which, with this exception, are marked out with ease, and are unexcelled for purposes of wagon transportation.

The supply of water over these arid tracts, except in a season of rain, is confined to a few isolated springs, occupying the lower level of some of these depressed valleys, or occasionally bursting out from the base of high rocky ledges. These springs, though generally affording a copious and constant flow of water, are not sufficient to give origin to river tributaries, their issue being quickly absorbed in the lower course of their arid beds. In several of these springs

the temperature is as high as 70° Fahrenheit. Between these watering places occur what are termed by travellers "*dry stretches*," being in some instances 50 miles in extent.

In all our observations thus far, little disturbance is noticeable in the position of the strata. To ordinary view they appear strictly horizontal; the indications of the barometer and the changes of the climate prove, however, a gradually increasing elevation. The height, as indicated at the Leon spring, the most western point of the continuous table-land at which cretaceous fossils were collected, is 2,807 feet. This shows a rise of 1,800 feet from the lowest series of this formation, (the mouth of Devil's river,) and 2,200 feet above San Antonio, giving an average rise of 7 feet to the mile.

Quite constantly in the distance, to the south and west, rugged mountain ranges are visible, evidently of igneous character, and connected with extensive disturbance of adjacent cretaceous rocks. It is through these, as we shall hereafter see, that the Rio Grande forces its way, presenting a series of chasms and deep cleft cañons of a most stupendous character.

The first indication of a change in the general features of scenery, as sketched above, on the line of the usually travelled road to El Paso, is encountered in the range of the "Sierra Diavolo," or Limpia mountains. This range may be regarded as the southern continuation of the great dividing ridge between the Pecos and the upper Rio Grande, including the Sacramento mountains to the north, the Guadaloupe and Limpia mountains, with their continuation south, to form the Sierra Rica of Mexico; through the latter portion of this range the Rio Grande forces its way a short distance below and east of Presidio del Norte.

This range is characterized, at all the separate points observed, by the presence of igneous rocks, varying considerably in structure and lithological character, as noted by Professor Hall in rock specimens Nos. 12, 13, 14, 15.

The elevation attained by this range, on the line of the El Paso road, is from 5,000 to 7,000 feet above the sea. On entering this range from the east, we pass quite abruptly from the horizontal limestone strata to the igneous exposures.

The passage of this range is accomplished by a series of rather steep and rough ascents, following up the course of the Limpia valley. The main pass, known as the "*Wild Rose Pass*," exhibits gigantic walls of rock, towering up on either hand to the height of 1,000 feet or more above the valley below.

The summit divide is composed of a coarsely-grained granitic rock, formed principally of feldspar, and varying in color, in the different exposures, from dark brown to a dull whitish. In descending the more gradual western slope of this range, the rock exposures assume the character of a close porphyritic trap, of a reddish color. As we leave the main range, passing to the west, we encounter extensive ridges of stratified limestone rock, associated more or less closely with interrupted igneous exposures, and showing a general dip to the southwest, or away from the Limpia mountains. The inclination, however, shows, in many places, a variable direction and intensity, depending on local causes connected with adjoining igneous exposures.

A degree of metamorphism is also exhibited in rock exposures, having a gneissoid structure and traversed by quartz veins.

From the specimens collected, imperfectly characterized by fossils, Prof. Hall concludes that these stratified rocks belong to the carboniferous period.

Between these irregular mountain ranges and spurs, which in this section of country meet

the eye in every direction, the intervening surface spreads out into wide basin plains of an alluvial character. These basins receive and absorb the scanty streams of the adjoining mountains. Rarely indeed, except in the highest mountain recesses, is running water visible, the occasionally copious rains furnishing only a temporary current along the course of the numerous stream-beds. The water thus accumulated in rocky basins or marshy lagoons, affords the only supply for travellers, over these arid wastes. During the dry season these plains spread out their dreary tracts, unrelieved by a single feature of fertility, occupied by innutricious grasses or a scattered growth of dry shrubbery, among which the repulsive form of the "*Spanish bayonet*" (*Yuca*) is a conspicuous feature. Owing to their exposed and elevated position, these plains are subject to great extremes of temperature. They are mostly shut off from the Rio Grande by a variable mountain range, composed of the carboniferous limestone, variously associated with igneous rocks. The passage to the valley is accomplished by following down the natural cleft made by some rain stream. These passes exhibit fine sectional views of the tilted limestone strata, exposed in various conditions of disturbance, in some places inclined at an angle of 80° to the west, and at other points exhibiting evidences of igneous action in metamorphic changes.

Eagle Springs.

We have thus reached, on the line of the ordinary wagon-road, the upper valley of the Rio Grande, the external features of which, as more directly connected with the line of boundary, will claim a more detailed notice. At first, however, a more rapid sketch must suffice, while continuing to notice the general features of scenery and geological structure presented on the route westward to the lower valley of the Rio Gila.

As we pass from the rocky cañon, by which we enter on the Rio Grande valley, we first come upon a gravelly plain, generally presenting a smooth and more or less uniform surface, sloping

gently toward the main bed of the valley. This plain, in receiving the drainage from the adjoining mountain ranges, is variously cut up by deeply-trenched arroyos, and terminates on the alluvial tracts below in gravelly bluffs of variable height.

This table-land is encountered wherever the course of the Rio Grande is not hemmed in by precipitous rocky cliffs, and is seen forming a belt of variable width on both sides of the river, extending to the base of the adjoining mountains. In all these situations it presents very uniform features.

An obvious analogy will be at once perceived between the latter formation and the widespreading upland alluvial plains, before noticed; in fact, a direct continuous connexion between them may be often traced. They evidently belong to the same general formation, representing basins filled up with alluvial and diluvial depositions, concealing, it may be, older tertiary strata below.

The pebbles contained in this formation can readily be traced to their original sources in the adjoining mountains, being of larger size and more angular near the base of the mountains, and smaller and more rounded at a greater distance. The earthy medium is generally a coarse sand or fine marl, argillaceous matter being less frequent. Occasionally the exposed bluffs show deposits of gypsum, which in some localities forms extensive beds. The most usual form of this material is in confused crystalline and fibrous masses, imbedded in loose marl. At other places a calcareous chalklike deposition is met with, occupying usually the upper stratum of the table-land.

A general *saline* character, pertaining to this formation, is also evidenced in the growth of saline plants or direct salt efflorescence in the lower depressions of valleys.

SECTION OF EARTHY TABLE-LAND FORMING THE BLUFFS OF THE RIO BRAVO ABOVE EL PASO, CORRESPONDING WITH THAT FORMING THE "JORNADA DEL MUERTO," TO THE NORTH.

A. Highly calcareous marl, chalklike, with occasional pebbles.
B. Brownish gray sand, with nodules of clay.
C. Yellow ferruginous marl.
D. Debris of drifted sand and washed clay.

As seen from any high mountain elevation, this table-land sweeps with all the exactness of a sheet of water, encircling as with a shore-line the bases of distant mountains, frequently completely insulating peaks and ridges, and everywhere masking the true connexion of the various formations.

The progress of subsequent drainage is also plainly seen in the various terraced elevations

which this table-land assumes. It may further be observed, briefly, that this is the formation that stamps the character of sterility on so large a scope of country forming those desert tracts known as "*Jornadas*," of which the "*Jornada del Muerto*" is a noted example. It is to this character of country, moreover, properly belongs the Spanish term "*Llano Estacado*," or *Staked Plain*, a term which has been less appropriately applied by travellers to the cretaceous table-lands of Texas, before noticed.

The proper alluvial tracts of the Rio Grande, as here met with on our route, exhibit a belt of variable width, from a mere narrow strip to several miles in breadth. Its lower portions are marked by frequent sloughs and old river beds. The body of the soil is sandy, but acquires a somewhat compact texture from the deposition of river slime, and is further enriched by the decaying vegetation that luxuriates on its moist bottoms.

The desert table-land is constantly encroaching on this alluvial belt, in the washing of its numerous stream beds, or the finest sand wafted by the winds. The roads occupying the river bottom are usually heavy, and whenever practicable are gladly exchanged by the traveller for the compact table-land.

The river itself presents few features of attraction. Its turbid waters sweep along during the flood season, in June and July, a swollen tide, spreading its enriching sediment through the various sloughs and lagoons that line its course, often cutting off all approach by land to the main channel. During low water, which includes the greater part of the year, the river contracts its dimensions, running in a very variable channel, over sandy shoals, interrupted by numerous islands and exposed sand-bars. Occasionally, in very dry seasons, it ceases to run altogether, and stands in stagnant pools.

The portion of the river bottom at present under cultivation in connexion with the El Paso settlements includes a large basin lying south of the El Paso mountains. In this is comprised the large alluvial tract known as "*The Island*," which is 30 miles in length by 2 to 5 in breadth. This island lies on the American side of the main channel, being separated from the adjoining land by an old river bed, which, except in very low water, still carries a variable stream. The bifurcation of these two arms of the river at the head of the island is taken advantage of to direct a stream of irrigating water through the centre of this tract of land, extending nearly its whole length, and furnishing from its main trunk side branches to supply the cultivated fields. Thus in usual seasons a sufficient supply of water is obtained to meet the wants of ordinary cultivation. At times, however, low water in the main channel is a certain precursor of drought; while at other times an unwonted abundance exposes to the danger of floods.

On the main banks of the river, including the Mexican town of El Paso, and Franklin, on the American side, these inconveniences are measurably obviated by drawing the irrigating supply from a higher source. This is accomplished by the construction of an artificial dam, located some two miles above these respective towns, thus allowing the construction of water-gates and waste-weirs to regulate the supply of water according to need.

Hitherto we have observed the Rio Grande in its character of a variable stream, bordered by alluvial bottoms frequently of considerable width and extent; these again everywhere limited by gravelly table-land, sloping upward to the bases of distant mountains. A short distance above El Paso a new feature presents itself, and we have the mountains themselves encroaching directly on the bed of the river, which here passes in a contracted channel between rocky walls.

The rock exposures on the river bank exhibit disturbed strata of limestone, characterized by frequent fossils as belonging to the *Cretaceous* period. A greater or less metamorphism of this or a more ancient sedimentary rock is also exhibited, while on either side of the river tower up to a height of 500 to 1,000 feet rugged igneous rocks, having a granitic texture, and characterized by Professor Hall as "feldspathic or granitic lava." (No. 40.)

View of the Initial Point, on Rio Bravo.

On the Mexican side, the various formations, stratified and igneous, are blended and intermixed in great confusion, the connexion between the various formations being obscured by the irregular exposure of igneous products, the greater or less degree of metamorphism of adjoining sedimentary rocks, and the presence of extensive diluvial deposits. The general surface is thus rendered extremely rugged and broken, the traversed roads being obliged to make a considerable detour from the course of the river.

On the American side is conspicuous a high mountain range, nearly parallel to the river, at a variable distance of from 3 to 10 miles, and observing a regular north and south course. This range is seen to be composed of stratified limestone, dipping very uniformly at an angle of 45° W.S.W., or toward the river; in the face of this dip rest the various igneous outbursts, associated with the disturbed cretaceous beds. This limestone is determined by Professor Hall to belong to the carboniferous series, being a northern continuation of that before noticed at Eagle Springs.

The remarkable character of the stratification is conspicuous at a great distance, its deep gullies presenting fine sectional views, and the different exposures of its sloping surface exhibiting variously curved lines, as the strata are thus brought to view by the action of the denuding forces.

The highest summit of this range presents a sharp, jagged crest, such as might readily be

mistaken at a distant side view for an igneous formation. Connected with this upper crest, we also notice outweathering masses of siliceous rock, (No. 38;) these frequently assume grotesque forms and positions, representing various tower-shaped prominences.

MOUNTAINS EAST OF RIO BRAVO SEEN FROM EL PASO.

A. Cretaceous rocks resting on granite, and diping at an angle of 10–15°.
B. Granite.
C. Carboniferous limestone.
D. Porphyry peak.
E. Drift.

At another point this mountain range is interrupted in its usual stratified character by the presence of a porphyritic exposure, (specimen rock No. 41,) forming a dyke, passing through the entire ridge from east to west, and constituting the highest point in this range.

This igneous mass is variously associated with the adjoining limestone strata, lying either above or below, without showing any local variation of the ordinary dip, or exhibiting metamorphic changes at the point of junction.

On its eastern aspect, this range exhibits a precipitous slope, revealing the thickness of the formation in the regular succession of the uplifted strata, as thus exposed, from summit to base; there is developed at several points a thickness of not less than 1,500 feet. No very marked change is observable in the character of the rock from above downwards, or any local evidence of a change of formation.

We have, however, evidence from erratic fossils of the presence of a lower order of rocks, belonging to the *Silurian* period, in this vicinity. Such a formation has been assigned to a corresponding location west of El Paso, by Wislizenus, and there is little doubt but a careful examination along the lower line of these uplifted strata would bring to light this lower class of rocks.

This range continues to the north, forming the Organ mountains, at which point these stratified rocks give place to various forms of igneous products, as indicated in rock specimens Nos. 42 to 46, inclusive.

About seven miles north of El Paso, the mountains adjoining the river give place to the more usual character of gravelly table-land and alluvial bottoms, as noticed below. The table-land is here seen swelling to its broadest dimensions, encircling the distant mountains in every direction, and stretches northward to form the dreaded "*Jornada del Muerto*," thence sweeping round the northern point of the Organ mountains, it constitutes the extensive desert tract between the Rio Grande and the Sacramento mountains. To the west the same formation is seen, variously interrupted by mountain ranges and isolated points of igneous rock, extending to the base of the Sierra Madre.

In further continuation of our general sketch of external and geological features of country,

we now take up the line of march westward, leaving the valley of the Rio Grande at El Paso, to follow out the most southern line of emigrant travel to the lower valley of the Gila river.

On leaving the alluvial basin, in which El Paso is situated, we first ascend over a lower step in the gravelly table-land, sloping gradually upwards, and presenting all the characters of scenery before described. We pass mountain spurs on the right and left, composed of the limestone rock, similar in appearance to the range noticed on the American side of the river, and having the same general dip to the southwest, but at a smaller angle.

Our route, following at first the regular Chihuahua road, passes nearly due south; in about 15 miles from the river we reach a second terraced elevation of the table-land, rising as a steep bluff 80 to 100 feet above the lower step over which we have been passing. The character of this higher deposit is here plainly exhibited in the face of the cliff, consisting of alternate layers of yellow ferruginous marl and coarse brown sand, capped with a thin layer of highly calcareous marl.

From the summit of this second elevation stretches a wide table plain, variously indented by shallow valleys, and swelling toward the base of the mountain ranges. On approaching the line of mountains lying to the southeast, we pass over a spur of limestone rock, connected with this range, showing a dip of 15° to the northeast, a similar inclination being apparent in the principal range. The rock formation appears to be identical with that before noticed near El Paso, having a directly opposite dip, thus forming a synclinal axis, in the trough of which our route seems to have been marked out. Leaving this latter range to some distance on our left, we approach a long serrated ridge of mountains lying directly in our course; near the base of the southeastern extremity of these mountains, occurs the first permanent water since leaving the Rio Grande, about 32 miles distance. This locality is the "Samalayurca Spring."

A short distance beyond this, commences the singular formation known as the "*Medanos*," or *Sand-hills*. They here rise conspicuously to view from the plain below, presenting an exact appearance of the sandy dunes along a stormy seacoast. It is difficult, at first sight, to disconnect this remarkable formation from such an obvious cause, and not to represent it as the sandy beach of the extensive lake in which the deposits were made, forming the wide expanse of table-land so often referred to. The present facts, however, do not warrant such an exclusive opinion; thus the separate grains of sand composing the sand-hills are seen under a lens to be angular, and not rounded, as would be the case in regular beach deposits; they are also extremely light and penetrating, of which every traveller who has occasion to pass this locality in a dry, windy day will have *ocular* demonstration. In fact, the peculiar features of this formation are sufficiently explained in the topographical arrangement of the country, which presents an immense plain, stretching out in the direction of the prevalent northwest winds.

In overlooking the surrounding country from the projecting point of the adjacent gneiss range, these sand-hills are seen to form a crescent, with its concavity toward the northwest, and rising highest where the accumulated deposit is most sheltered by rocky barriers, from the levelling influence of winds, other than those from the northwest.

The spring which occurs in this locality near the base of these sand-hills occupies a natural depression of the general plain. Its issue spreads in a shallow pool surrounded by aquatic plants and shrubbery. The central spring source forms a deep hole, about two feet in diameter, bedded with quicksand, which is surges up intermittently at various points. The temperature of the water is 70° Fahrenheit.

On entering the sand-hills from the north, we first pass over a considerable swell of limestone rock, from the southern slope of which we pass at once into the hills of sand. Its surface, at first variously scattered with arid shrubbery, becomes as we proceed almost pure drifting sand, blown by the wind into varying ripple-marks, and assuming all the different shapes of drift and hollow imaginable. As the view of the surrounding country becomes shut out, there is presented an exact picture of the sandy dunes on an exposed seacoast, and it seems almost strange not to hear the roaring of the surf, or catch a view from the highest elevations of a wide ocean expanse.

The greatest height of this formation is on the southern side, or in the convexity of the arch, which terminates with a somewhat abrupt face, merging into the shrubby plain below.

Our route from this point leaves the Chihuahua road, passing more to the west, and thence skirting along the base of jagged mountains, forming a broken range to the south and south-west. The plain traversed is similar in character, and continuous with that on the opposite side of the sand-bills, having, however, an increased elevation. Our route, bearing S.S.W., is interrupted by occasional spurs of limestone rock, proceeding from the adjoining mountains to the south.

This character continues for some twenty miles, when we begin to notice an obvious change in the external features of the country. The frequent valleys leading from the broken mountain range on our left acquire a more fertile character, and, being removed from the incursions of drifting sand, support a richer growth of plants. Beyond this, the country spreads into wide basin plains, presenting to the eye an uniformly smooth outline. The soil is composed of a stiff clay sediment, and is occupied exclusively with a growth of coarse grasses. In their lower depressions these extended plains frequently present a perfectly bare surface, destitute of all vegetation, the retentive soil either holding the product of recent rains in wide, shallow pools, or more often showing a surface cracked and blistered under the influence of an arid atmosphere. We find frequently scattered over its surface recent land shells, as indications of its lacustrine character. In certain localities these lower depressed flats are covered with a white saline efflorescence, resembling at a distance sheets of water, to the frequent disappointment of the thirsty traveller. The roads leading over these tracts are firm and excellent. The natural supplies of water are very inconstant, being in great measure dependent on rains.

Our road hence, for a long distance, traverses a succession of these plains, of greater or less extent, alternating with short ridges, occasioned by the passage of an irregular mountain range.

These ridges present along their line of elevation various depressions, at which the passage is generally accomplished by an easy gravelly slope. The exposed rocks are of carboniferous limestone, associated with various igneous products.

This character of country continues till we reach the first flowing stream yet encountered on our march from the Rio Grande; this is the *Rio Sta. Maria.* As here exhibited, it shows a flowing brook of limpid water, from 10 to 20 feet in width; at the crossing knee-deep, and flowing over a pebbly bed. Its source lies far to the south, in the State of Chihuahua; thence flowing north, it empties, about 30 miles from our place of crossing, into Lake Sta. Maria. This lake is shown, by the examination of the boundary commission, to be in close proximity to the larger Lake Guzman, from which it is separated by a range of mountains.

These lakes, though thus separated, belong to the same general basin, receiving the drainage of a large tract of country—the San Miguel and its tributaries entering on the north, and the

Sta. Maria on the south. The waters of these lakes having no outlet, are strongly impregnated with saline substances, so as to be unfit for drinking.

The adjoining mountains on our route are of igneous character, being composed of vesicular and amygdaloid trap, forming more or less continuous ridges, ranging north and south.

Associated with the fact of running water in this region, we see the country characterized by an unwonted appearance of fertility and verdure, not alone confined to the immediate borders of the stream, but extending over the hills and plains adjoining.

Our route, after crossing the Sta. Maria river, takes a course S. 70° W., (mag.,) passing over country characterized as above, bounded by mountain ridges of less height above the general surface than those before passed. The greatest development of mountain range lies to the west. The various rock exposures exhibit most abundantly forms of amygdaloid trap; more rarely we meet with local exposures of limestone strata, or variable metamorphic products.

Conspicuously in view in our direct course are the mountains in which the silver mines of Corralitas are located, consisting of an assemblage of rounded and peaked summits of various heights, rising from 500 to 1,500 feet above the adjoining plain.

These mountains occupy an area of about 5 miles in length from north to south, and 2 to 3 miles in width. They rise isolated in the midst of a broad alluvial plain, sloping gradually on the east and west towards the respective valleys of the Sta. Maria and Corralitas rivers. A wide intervening depression also separates them from higher mountain ranges north and south. The latter mountains present a marked contrast in their precipitous sides and exposed rock of a basaltic character to the uniform smooth outline of the mineral-producing mountains. In these latter, indeed, the geological formation is everywhere concealed from view by a variable deposite of earth and gravel; thickly covered with a growth of grass. It is this fact which has probably given to these mines their Spanish appellation of "*Minas del mineral de la Escondida,*" or hidden mines.

The mines at present worked occupy the most northern point of the mountains, though mineral indications and abandoned excavations are common over the exposed face of the whole mountain range. The various excavations bring to view a very uniform character of formation, first passing through a variable layer composed of angular fragments of rock, imbedded in a dry brown earthy medium. The superficial rock exhibits a siliceous limestone of very close compact texture and dark blue color; to this succeeds the true silver-bearing rock, being a form of subcrystalline limestone showing the action of internal heat, of a much softer texture than the preceding, and of a whitish gray color, (specimen rock, No. 99.)

In this latter rock are exposed the veins of argentiferous galena, frequently extending into the upper siliceous rock, but acquiring its greatest thickness and richness in this lower formation.

The veins of mineral penetrate this rock in the form of variable sheets, dipping regularly at an angle of 45° to the northwest.

Further details in reference to the character and working of these mines, with such reliable mining statistics as could be procured, will be found under a separate head.

From the mines, by a gradual and continuous descent over a wide grassy plain, scattered with low mezquite bushes, we have in view at the lowest depression the valley of the San Miguel or Corralitas river, and the towns of Baranca and Corralitas. This plain, though usually dry,

supports a fine growth of nutricious grasses, and the mezquite bushes, which are scattered over its surface, are the main dependence for the necessary supply of charcoal for smelting operations. To first view, this would seem to offer but a poor supply of this needful article, showing in such situations only a shrubby growth; but owing to a remarkable peculiarity of this variable and wide-spread shrub, it is found that, when growing in such exposed situations, instead of developing a distinct trunk, it forms thick underground stems. These being grubbed up by a class of peon laborers, are disposed in piles to dry, when they become fit for conversion into a superior article of charcoal.

At a distance of 20 miles over the above described plain we reach the valley of the San Miguel river; on the eastern bank of which, at a distance of three miles apart, lie the towns of Corralitas and Baranca. We here encounter a beautiful limpid stream and a fertile valley. At Corralitas, this river, as seen by us in the month of February, and again in April, 1852, had an average width of 30 feet, and 2 feet in depth, flowing over a sandy or pebbly bed between shallow alluvial banks. The season of high water is said to be in September, corresponding with the close of the rainy season; at which time a large portion of the adjoining bottom-land is overflowed, the greater part of which is susceptible of cultivation. The width of this alluvial belt is variable, being occasionally spread out in low marshy tracts, 3 to 5 miles wide; at other places contracted by the encroachment of mountains on either side. Some 16 miles above Baranca, to the south, are the remains of ancient and extensive structures, known as "Casas Grandes," still occupied by a flourishing agricultural settlement under the same name. A similar character of mountain ranges, as before noticed, bound the valley on either side; being, however, composed exclusively of igneous rock, the higher peaks showing generally a basaltic structure. The towns of Corralitas and Baranca are built up exclusively with a view to mining operations, the ore being transported to these places for smelting and refining. Living in a state of constant warfare with hostile Indians, the raising of cattle, or even the cultivation of the soil, is confined to a bare supply of necessaries. Abandoned fields and deserted ranchos are frequently met with, showing a quite recent period of greater prosperity, the decline of which is most evidently due, not to the natural incapacity of the country, but the inefficiency and degeneracy of its population.

In a direction W.N.W. from Corralitas, and about 24 miles distant, is the town of Janos. Our road to this place, after crossing the Corralitas river, leads at first over the wide grassy bottom-land of its western side, here nearly 5 miles in width. From this we pass over a ridge projecting into the valley below, and descend again on its opposite slope, following near the course of the lower valley, and passing over a shrubby plain similar to that before described; forming a sort of table-land gradually sloping toward the river. The town of Ianos is situated on a branch of this main stream flowing from the southwest. On reaching the banks of this latter stream, we find a mere rippling brook running over a pebbly bed. A short distance below, its waters are drawn off for the purpose of irrigating the gardens and cultivated fields which occupy the delta formed at the point of junction of the Janos branch with the San Miguel river. The town is situated on the gravelly table-land on the left side of the stream overlooking the river bottom, and set off in the background by a range of high mountains shutting out the view westward. Our route leads directly toward this western mountain range, which is crossed at a low depression, thence descending into still another wide basin plain,

extending in its greatest length from north to south, and bounded on the west by the clearly defined range of the Sierra Madre.

The course we travelled thence lies W.N.W., inclining towards this mountain range, and crossing diagonally the wide basin plain intervening between this and the Janos range of mountains.

About 10 miles from Ianos we come upon a singular depressed valley, sunk some 50 feet below the gravelly plain, having a lower alluvial belt about a quarter of a mile in width, which is coursed by a limpid brook, and bordered by a scattering timber growth.

This stream is said to have a lagoon source some three miles to the southwest; thence flowing northeast 10 or 15 miles, it terminates in a marshy lake surrounded by mountains; thus showing a character similar to that before noticed in reference to Lake Guzman and Sta. Maria on a smaller scale.

From this point, following a continuous course W.N.W. (mag.,) the road passes over a gently undulating swell, composed of gravelly table-land, thence crossing a wide, open, alluvial basin, similar in character to those before described.

We then approach the high mountain range of San Luis. Our progress toward the mountain base leads by a gradual ascent till a near approach brings to view deep gullied stream beds, connected with the drainage of the mountain valleys, and terminating on the alluvial plains below. Near their sources in the mountains these ravines contain running water, more or less copious, according to the character of the season.

On reaching the first rocky spurs from the main range, the country assumes a most picturesque character. Clumps of *live oak* (*Quercus Emoryi*) edge the ravines, and are scattered along the mountain slopes. Cedar of a shrubby growth is also frequent, and the usual mountain shrubbery serves to give a character of freshness and verdure to the scenery.

Directly at the mountain base, and forming its projecting spurs, a reddish form of porphyritic basalt makes its appearance, showing a precipitous columned face and tabled summit.

In the recesses of the ravines, as exposed by the mountain torrents, a variable deposite of igneous conglomerate is met with, flanking the central rocky mass. This central nucleus, as exhibited along the sides and summit of the mountain range, is an igneous volcanic product of quite recent origin, and characterized by Professor Hall as "feldspathic lava," exhibiting a granitic appearance. (No. 86.)

At the point where the old road crosses the ridge, called the "San Luis Pass," the ascent is quite abrupt, rising from the plain below 800 to 1,000 feet.

The summit crest commands a most extensive and grand view. Looking eastward, the eye takes in at a glance the wide alluvial plain over which we have been passing, encircled by its irregular mountain boundaries, showing plainly its basin character, and in which here and there stand out isolated mountains, as islands in the broad expanse.*

To the north and south is a continuation of the main ridge, more broken to the north, and apparently forming slopes of easier ascent than the one passed over by us. Quite possibly at several places there may be an easy transition from the plains on one side to those of the opposite slope. To the south the range is more continuous, of a rugged character, and increased height.

* This description was written before the line under the treaty of 1853 was run. It will have been seen in the preceding part of this work that good passes were found to the north and within the limits of the United States. W. H. E.

Westward we look down on another alluvial plain, less distinctly bounded by mountain ranges, and extending to a great distance from north to south. On its western limits, at a distance of about ten miles, this plain abruptly terminates by a slightly elevated terrace, the descent from which to the lower level of the San Bernardino valley forms the well known Pass of Guadaloupe.

Here, then, we have the means of estimating the true character of this great water-shed, in its connexion with the present line of boundary both to the north and south.

Considerable confusion has arisen from the vague terms and expressions employed by writers to describe the peculiarities of this part of the central axis of the North American continent. There has been wanting in their popular descriptions the elements of a general principle, applicable alike to all great dividing ridges. Geological science alone furnishes this element, giving, in the general result of its observations, the best means of elucidating all the points involved, and clearly explaining the several local peculiarities exhibited.

In most of the descriptions hitherto given of this portion of the dividing ridge, we hear in frequent use the stereotype expressions that at or near the point under examination the range of the Rocky mountains becomes "suddenly depressed," or "flattened out," to form the great Mexican plateau. Again, that at some imaginary point south of this great change of topographical features rises another distinct range, called the *Sierra Madre*, continuing thence to form the line of cordilleras extending to the extreme of the continent.

Now, such descriptions as these embody no clearly defined principle of geological science, and contain, moreover, errors of fact.

The Spanish name of *Sierra Madre* (literally *mother mountains*) is the general term in use to describe what is called a *dividing ridge* with us, and its special application to the range under consideration is due to the important character of this divide as the *mother range* of the continent.

Now, it is well known that all extended continental ranges are due to a line of internal disturbance, of varying intensity at different points, but in all alike characterized by the protrusion of various igneous products, together with the uplifting of adjacent stratified deposites, either altered in texture by the action of internal heat giving rise to the various metamorphic products, or showing the action of an uplifting force only in changes of inclinatian or dip of the strata.

Most naturally, then, in view of the numerous and varied agencies at work, should we expect changes of character at different points of the same range, corresponding to points of greater or less intensity of the internal disturbance, or the different products erupted or exposed to alteration. Hence occur elevations and depressions, and variety of formation in the course of the same continued range.

With this principle in view, we have a ready explanation of all the peculiarities exhibited in the portion of the range under examination.

Thus the igneous products are mostly of modern origin, exhibiting various volcanic products in the form of granitic lavas, porphyritic basalts, and amygdaloid traps. These products show a very variable character of exposure, forming ranges irregular in their direction, and differing in composition.

These several mountain ranges cover more or less the entire face of the country, including the dividing ridge only as one member of the general series.

The natural explanatory inference from these facts is, that the internal force, here represented in the continued mountain range, was diffused over a large space, and not centralized on one particular line. Hence arises no great prominence of one central chain, but a number of independent ranges, serving to equalize the general elevation and give the character of an elevated plateau to the surface of the country.

Again, the same irregular action of the internal force, and especially the preponderance of recent eruptive products, favors a varied direction of the mountain ranges, by means of which areas are circumscribed and basins formed for the reception of aqueous depositions. Here, then, we see the origin of those extensive plains and stretches of table-land to which our attention has been so frequently directed in the preceding sketch.

These same characters probably apply more or less closely to many other localities connected with the general dividing range, whether north or south of the point we are examining.

We are now prepared to descend the western slope of this dividing ridge, and note the peculiarities of feature presented on our route westward.

Decending, then, by an equally steep slope as the eastern ascent, and about the same height, we come upon the alluvial plain below. The lowest depression of this plain is composed of a light alluvial soil, and thence sloping gently upward to the west, exhibits a gravelly deposit, till, at a distance of about eight miles from the base of the mountain just left, we come upon the abrupt descent of the Guadalupe Pass.

This noted pass, which has been so frequently traversed on the line of emigrant travel to California, is now so well known as hardly to need a detailed description.

This pass has been properly characterized as the first step of considerable descent from the Mexican plateau to the heads of valleys leading to the Californian gulf. It has now been clearly established that at a point farther to the north, near the parallel of 32° latitude, the descent westward may be accomplished by a more gradual slope, and without leaving the basin of drainage pertaining to the Gila river.

The geological structure exposed in this mountain pass is similar to that before noted as occurring in the upper slope of the Sierra Madre, including feldspathic lava, granitic in texture, associated with basalt, stratified porphyry, and closely cemented breccias.

These several forms, variously associated, serve to give a remarkable diversity and broken character to the rock exposure, presenting a confused outline of mingled crests, peaks, and ravines. Through these the road has to work its way by sharp turns and very steep descents. On attaining a lower level we pass down a ravine, gradually widening, which finally spreads into a small valley, watered by a fine running stream, and beautifully shaded by large sycamore and cotton-wood trees. This valley is closely hemmed in by steep rocky walls, marked by intricate ravines, and rendered picturesque by a varied assemblage of *live oak*, *cedar*, and other verdant shrubbery. In emerging from the higher points of the mountain range, the walls of this cañon exhibit various forms of stratified porphyry running into a breccia. The character of stratification has, at several points, a close resemblance to altered sedimentary deposits, showing a reddish color and a very uniform character of dip.

We finally leave this valley, mounting up a steep bank, composed of gravelly table-land, rising 200 feet above the bed of the stream, thence passing by a gradual and continuous slope toward the main valley of the San Bernardino. The table-land here has all the usual characters of this

formation in other parts, not differing essentially from that of the Rio Bravo or Gila valleys, and terminates by an abrupt bank, bounding the alluvial basin below.

This basin, forming, as it is said, the head of the Yaqui river, here shows a wide flat plain, extending from north to south, and having a breadth of three to five miles. On its western edge is situated the deserted settlement of San Bernardino. Adjoining this rancho are numerous springs, spreading out into rushy ponds, and giving issue to a small stream of running water. The valley is covered thickly with a growth of coarse grass, showing in places a saline character of soil. The timber growth is confined to a few lone cotton-wood trees scattered here and there.

Signs of previous cultivation are limited, this settlement having been engaged principally in stock raising. The numerous bodies of wild cattle now running at large over this section of country are the remains and offspring of domestic herds, now widely scattered and hunted by Indians.

The western side of the valley is precisely similar to its opposite, showing the same general character of gravelly table-land. This leads by a gentle ascent to a low point in the dividing ridge separating the valleys of San Bernardino and Aqua Prieto.

A remarkable tower-shaped peak rises in the centre of this ridge, a short distance south of the road, forming a conspicuous landmark. This ridge is seen to be composed of one or more of the variable forms of volcanic products so often noticed heretofore; the prevailing character is here a reddish brown granitic mass.

The descent on the opposite (western) side of the ridge to the alluvial bed of the Aqua Prieto is over a long, tedious slope, the gravelly table-land giving place to extensive tracts of clay or loam, supporting a patchy growth of coarse grass. The "Black Water" valley, at its lowest depression at this point, contains no constant running stream, its course being mainly occupied with low saline flats or rain-water pools. Extensive lagoons are said to occur in this valley a short distance south of where the road crosses.

The main tributary to this valley comes from the west, and is followed to its head on the line of wagon-road. Its bed consists of a wide ravine, coursing through pebbly strata, variously marked by the washings and drift deposits, caused by the occasional strong current derived from local rains. At other times its bed is entirely dry. The timber growth along its borders consists of hackberry and walnut.

At its source there is a fine spring, issuing from ledges of stratified porphyritic rock, identical in character with that noticed at the foot of the Guadalupe Pass. The stratification is inclined to the northeast, and along the line of its tilted ledges the spring issue forms frequent pools of limpid water.

From this point we pass in a circuitous course to the southwest, winding among rocky spurs, and thence passing up an upland valley, agreeably diversified with groves of live oak and covered with luxuriant and nutritious mountain grasses. On this route we pass gradually to a divide which leads, on its western aspect, to an eastern branch of the Upper San Pedro valley.

The country here begins to assume most attractive features. To the north and west rise high mountain ridges clothed with pine and oak groves; the intervening country is everywhere carpeted with fine grama grass, the nutritious quality of which is exhibited in the well-conditioned character of the numerous wild horses and cattle that luxuriate over this favored region. Water

is frequent in the valleys, and everything indicates a capacity for cultivation, the grazing capabilities being unequalled by any tract heretofore passed over.

Beyond this the San Pedro valley spreads out in diverging branches to the east and west, thus drawing tributary a very extended mountain drainage.

It is this latter character which sufficiently accounts for the fact that the San Pedro is the only branch of the Gila River, coming from the south, which furnishes an uninterrupted stream of running water along its whole course.

At the point where the main valley of the San Pedro is reached we find an alluvial belt, variable in width, and occasionally marshy. These bottoms are flanked by terraced table-land of unequal heights, composed of a hard gravelly soil, and supporting a close sward of grama grass, giving a peculiarly smooth shorn look to the general face of the country.

Occasional exposures of igneous rock, or the projecting spur of some mountain ridge, serve to diversify the scene; and quite constantly in the higher branch valleys is exposed a form of igneous conglomerate. This latter formation is exposed in irregular bluffs along the edges of these valleys, presenting washed faces and precipitous walls crowned with terraces. These higher points are frequently set off with the remains of deserted dwellings, plainly located with a view to defence. Other eminences, commanding extensive views, are occupied by rocky breastworks, serving the double purpose of watch-towers and strongholds of retreat. Associated with these are also extensive rocky enclosures, in which the cattle were secured. All these points are suggestive of the condition of constant warfare to which this commencing civilization was subject, and under which it was at last obliged to succumb.

These upland valleys are only sparsely wooded by occasional cotton-wood or walnut trees. As we approach the mountains, however, the timber growth becomes more abundant, and the lower ridges are occupied by extensive groves of oak, which, on the higher points, are associated with pine and cedar.

From the head of the "Nutria" (southwest) branch of the San Pedro, up which our road passes, we commence the steep ascent of the mountain ridge lying between the Santa Cruz and San Pedro valleys. The character of this range is exactly similar to what we have before described as pertaining to all the higher mountains passed over on our route, west of the Sierra Madre.

The height of the pass leading to Santa Cruz is not less than 1,000 feet above the respective valleys on either side, being equally steep and rugged on either slope. The same ridge, extending toward the south and southwest, forms a continuous line of high mountains, lying between the San Pedro and Santa Cruz valleys; the preferable route for crossing is probably that taken by Col. Cooke in 1846.

The upper route, being the one more commonly followed, strikes the Santa Cruz valley near its head source.

The direction of this valley is at first nearly due south, giving the idea that its drainage is on the line of the rivers flowing south to the California Gulf. It is indeed so laid down on most of the maps of this region, but this is manifestly incorrect. About three miles south of the town of Santa Cruz the valley makes a sharp elbow; thence doubling on its former course, it continues north and northwest, being the same valley in which, lower down, are

located the towns of Tubac and Tucson; thence leading toward (though probably hardly ever reaching) the Gila River, near the Pimo settlements.

The situation of the town of Santa Cruz is highly picturesque, lying embosomed amid lofty wooded mountains. Its soil is fertile, abundantly watered, and susceptible of easy irrigation; its elevation gives it a cool temperature, suited to the production of northern fruits and cereal grains.

A cut-off, over the mountain range intervening between the two courses of the river, leads, by a distance of 18 miles, to a lower part of the valley, maintaining in the main the same general features, but showing a marked change in the climate. This latter fact becomes still more apparent in our progress downward, as shown by the comparative forwardness of vegetation. Thus a short journey of three days (or 80 miles) from Santa Cruz, between February 27th and March 1st, 1852, showed a difference in the advance of vegetation equal to a full month in time; so that while at Santa Cruz the cotton-wood trees were barely budding, the first day's journey displayed their loose catkins, the second the opening leaf, and the third the full leaf.

Greater aridity also characterizes the lower portion of the valley, and the live oak, so common above, gives place to heavy growths of mezquite. The adjoining mountains on either hand become in great measure bare of trees, and present steep ledges of igneous rock exposed along their broken range. The immediate edges of the valley are flanked by a conglomerate formation, similar to that noticed on the Upper San Pedro. Accompanying these changes the stream contracts, and finally, in certain points along its course, ceases to run, and the usual desert features of all waterless tracts in this region are exhibited.

We thus pass the settlements of Tomocacori, Tubac, San Xavier, and Tucson, together with numerous deserted ranchos occupying various points along the valley. After leaving Tubac, which is situated about midway between Santa Cruz and Tucson, the valley expands into a wide open basin, the mountains receding on either hand, and the dry valley, now almost exclusively occupied by mesquite, is bordered by a wide stretch of gravelly table-land. On this table-land we meet, for the first time on our route, that most remarkable vegetable production, the *Cereus giganteus*. Further on it becomes abundant, its stiff trunks and branched arms rising up here and there like sentinels, and giving a most peculiar character to the landscape scenery.

Approaching the town of San Xavier, noted for its superb church, contrasting strangely with the mud hovels surrounding it, we again come upon running water, with its constantly associated fertility and verdure. In this vicinity occur rocky knolls, composed of a dark-colored trap-rock, which formation becomes still more largely developed in the vicinity of Tucson, forming extensive ridges having a tabulated form and very irregular outline.

The settlement of Tucson occupies the lowest line of constant running water, and consequently the last fertile basin lying in the course of this valley. Below this, on the north, succeeds the extensive desert tract lying between Tucson and the Gila River.

In pursuing our course down the valley, the adjoining table-land gradually merges into the desert plain over which our road passes. Hardly, however, did it seem to deserve the name of a desert at the time of our crossing it. Owing to the refreshing influence of recent rains, a rapid growth of evanescent flowers gave its otherwise barren surface the aspect of a flower garden, regaling both the sense of sight and of smell with a profuse and varied assemblage of tints and scents. Water sufficient for our animals was found in ravines by the side of the road, and

a journey of eighty miles, otherwise dreaded, was, by an agreeable disappointment, rendered highly pleasant. Our journey was made in the first week in March; doubtless another month might have changed its features materially.

Our course lies quite regularly to the northwest, a broken line of mountains lying on our left, while to our right lies the extensive high mountain range northeast of Tucson. Directly in our course is a singular pinnacled peak, being the "half-way point" between Tucson and the Gila; approaching this, we pass by a gradual ascent over a gentle ridge, forming a depressed point in a continuous mountain range extending from the pinnacled peak, on our left, northeast toward the Gila valley. Near the summit of this ridge we pass small alluvial tracts, then occupied by a luxuriant growth of young grass, and cut up by deep gullies containing abundant supplies of rain water. The rock exposure here has a more ancient appearance than any before passed, indicating an approach to the granite ranges of the Californian Cordilleras.

We descend the northern slope of this ridge, passing over extensive clay flats washed by recent rains into frequent gullies, these finally centering in one form the irregular bed of a rain stream leading direct to the Gila river.

The portion of the Gila valley thus reached is where the river, emerging from the high mountains occupying the mouth of the San Pedro, spreads out into the extensive alluvial bottoms, occupied in part by the settlements of the Pimo and Maricopa Indians.

The gravelly table-land here forms a gentle slope, leading from the distant mountains, and indenting the alluvial belt below. This latter consists of an upper level, supporting a shrubby growth of mezquite, and a lower bottom subject to river overflows. On these upper portions the Indians usually construct their dwellings, thus overlooking the lower cultivated fields. The amount of land here capable of cultivation is quite extensive, forming a belt on each side of the river often several miles in width, and extending east and west for 20 miles or more.

The stream of water, then at its average height, (in early March,) measured about 40 yards in width with an average depth of 2 feet, the volume, however, being considerably diminished by the extensive irrigating ditches drawn from above.

The line of the river bank is at this season set off with lagoons and marshes, and everywhere bordered with a dense willow growth, rendering it difficult of approach.

The dams, which serve the purpose of drawing off the irrigating water, are constructed of old willow trunks and snags; these, in the course of time, entangling the loose soil and sediment borne down by the river, furnish a bed for the willow growth, thus becoming more permanent with age.

From a rock knoll of true granite, abutting on the river on the American side, a fine view is obtained of the general character and external features of this interesting locality.

The character of the Gila valley, from this point down to its mouth, did not come under my personal inspection. All accounts represent a great uniformity of general features already sufficiently detailed.

Thus we have a succession of basins, limited by mountain barriers, through which the river forces its way, forming cañons of greater or less extent.

These basins are again occupied by more or less extensive stretches of gravelly table-land, representing the desert features of this region; through these are marked the alluvial tracts,

varying in width and character according to the geological conditions surrounding them; through this the river works its sinuous course, with a swift current and turbid water, till it empties into the Colorado of the West.

IV.—MINERAL PRODUCTIONS OF THE REGION OF COUNTRY, IN CONNEXION WITH THE MEXICAN BOUNDARY LINE, FROM THE MEXICAN GULF COAST TO THE COLORADO OF THE WEST.

[NOTE.—This report was written before the treaty of 1853, and applies more particularly to the old boundary under the treaty of Gaudalupe Hidalgo.]

The mineral productions of the region of country, in connexion with the United States and Mexican boundary line, are necessarily various, as corresponding to the different geological formations. The detailed examinations necessary to furnish a satisfactory estimate of the real value of this class of products are still wanting, and the peculiarities of the country itself place great obstacles in the way of arriving at clear results.

Among the most important, which we may here briefly enumerate, are: *First.* Such as are connected with the various forms of igneous and metamorphic rocks, including *Copper*, *Gold*, *Silver*. *Second.* Such as pertain to the stratified or alluvial deposites, including *Coal*, *Salt*, *Gypsum*.

FIRST CLASS.

COPPER is quite frequently found in connexion with porphyritic rocks. The most usual form of the ore is that of *green malachite* and *red oxide*. The locality best known is that of *Santa Rita del Cobre*, which was profitably worked about 20 years ago. Analysis of ore from this locality exhibited a yield of $75\frac{36}{100}$ per cent. of copper.—(See analysis by Professor T. Antisell.)

No mine of copper is at present worked in any part of the region under examination.

GOLD is said to be sparingly found at various localities, in connexion with diluvial deposites, derived from adjacent igneous rocks. It is here met with in a finely disseminated state, and has never yet been found in sufficient quantities to yield a fair return for the labor expended. It would seem here to belong to the same character of formation as that of Mexico, associated with forms of porphyry, and never to approach in richness the deposits of California; such, indeed, we would expect in the general absence of metamorphic slates and quartz veins, so well known to be the most prolific source of gold in other regions. But one locality of the true gold-producing rocks was met with on our route, and that was at the furthest western point, near the Pimo villages, on the Gila.—(Specimen rock, Nos. 97 and 98.)

SILVER.—Silver ore is found at several localities, mostly on the Mexican side of the line. It has also been found in the Organ Mountains and various portions of southern New Mexico. The localities best known in Mexico adjoining the boundary line occur at Corralitas and Presidio del Norte, in the State of Chihuahua, and at Santa Rosa, in the State of Coahuila. The only one at present successfully worked is that at Corralitas, before referred to. The ore from which the silver is obtained is a form of *Argentiferous Galena*, containing very variable proportions of silver. According to the statement of the principal proprietor of these mines, *Mr. Flotte*, the average yield of the best mineral is 0.50 per cent. of silver; analysis of a single specimen by *Professor Antisell* gave only 0.03 of one per cent., a discrepancy difficult to account for, except on the supposition that the ore varies remarkably in the relative amount of contained silver.

The working of these mines is carried on in a very rough manner. The excavations simply commence with the surface exposure of the veins, thence following them down by rude and irregular shafts, inclined according to the dip of the vein, at an angle of 45° to the northwest. The ore is extracted by blasting, both the mineral and the refuse material being brought up on men's backs. Where the depth is such as to cause an accumulation of water the mine is abandoned.

The richest of these distinct mining excavations is that called "*San Pedro.*" This, when visited in 1852, had attained a depth of eighty yards. The mineral vein, as exposed along the line of excavation, exhibited a very variable thickness, from one to twelve inches; the character of the ore and its specific gravity also varied at different points.—(See description and analysis by Professor T. Antisell.)

The mode of extracting the silver is by a double process of *smelting* and *refining*. By the former the ore is reduced, by the means of a common furnace, to the form of an alloy of lead and silver. In the refinery the lead is removed by burning it out in a blast furnace, leaving the silver in the shape of irregular cakes, weighing about eight ounces each. The refining process occupies about twelve hours.

The following information in reference to the working of two of the principal mines and reducing establishments and the amount of silver produced is furnished by the proprietor, *Mr. Luis Flotte, of Baranca.*

The mine of San Pedro employs about forty men, whose wages average $10 per month. The amount of ore extracted by this number of men monthly is from 160 to 200 loads, of 300 pounds each. This is calculated to yield from 24 to 32 ounces of silver per load. The average monthly expense of working this mine is about $1,000.

The mine of Leon employs about the same number of men, and requires the same expense of working, viz: $1,000 per month. The amount of mineral extracted from this mine is about 500 loads per month, of 300 pounds each, estimated to yield three ounces of silver to the load. This ore is chiefly valued as a flux to assist in the reduction of the richer mineral.

Smelting Establishments and Refineries.

There are two of each of these establishments in operation at Baranca. The number of men employed in all the necessary labor, including hauling the mineral, manufacture of charcoal, &c., is 125. The average monthly expense is $2,000.

When in full operation, the amount of ore smelted is 180 loads of San Pedro ore, and 500 loads of Leon mineral, of 300 pounds each. Total, 204,000 pounds per month.

The yield of silver for this amount of ore would be an average of 420 pounds, at $16 per pound, equal to $6,620, leaving a profit for capital invested of $2,620 per month. The total amount of silver produced at this mining location for six years ending January 1, 1852, as given by the two proprietors, is—

Mr. Luis Flotte, at Baranca	$340,000
Señor Don José Maria Zuloaga, at Coralitas	146,000
Total	486,000

COAL.—A remarkable form of coal, closely resembling *cannel coal*, is found in connexion with the cretaceous strata on the Rio Grande, being exposed at several points along the course of the river from the mouth of the Pecos to Laredo. The character of the formation and economic value of the product, as an article of fuel, will be given in the report of Mr. Schott.

SALT occurs in connexion with salt lakes, occupying depressed portions of the wide desert tracts, to which the term of *Llano Estacado* is applied. The product is more or less pure, and in greater or less abundance, according to obvious local causes.

GYPSUM occurs in connexion with marls, belonging either to the upper Tertiary, or alluvial series of deposits. In such situations it frequently forms very extensive beds, composing the main bulk of local table-land exposures.

In concluding this report, I have to express my special obligations to Professor James Hall, of Albany, who has kindly favored me with his views of the geological collections of the survey, and otherwise rendered assistance in making out this report. Similar acknowledgments are due to Professor John Torrey, of New York, in reference to the botany.

Especially, in this final conclusion of my duties on the Mexican boundary survey, are my sincere thanks due to Major W. H. Emory, with whom I have been directly associated, in field and office duties, for the last five years, a length of time signalized by repeated and considerate acts of kindness on his part, as my superior officer, and gratefully remembered on mine.

Respectfully submitted.

C. C. PARRY, M. D.,
Botanist and Geologist U. S. B. C.

I consider the present a proper place to insert the analysis of minerals, not only of those referred to by Dr. Parry in the above memoir, but those which were collected in the new Territory subsequently to his withdrawal from the commission.

In the Organ Mountains, near Fort Fillmore, and at several other places along our route, silver mines have been opened by enterprising Americans, but I have not obtained analyses of the minerals procured at them, for the obvious reason that the experience of the miner will be a more valuable test of the value of the mine than any which can be afforded by specimens.

Nothing can be a more fallacious test of the value of a mine than the analysis of pieces of ore taken at random from the metallic vein, as most of these have been. Its true value can only be arrived at by actually working the mine, which, for the purpose of experiment, may be carried on upon a very limited scale.

Those familiar with the localities will see in the analysis that specimens from veins of known value are here exhibited as yielding a very low per cent. of precious metal. These specimens are therefore not fair examples of the whole.

When at Janos, I observed the inhabitants collecting nitre from the soil by the rudest process, and was informed that all the powder used in blasting at the mines of San Pedro was manufactured from the nitre thus obtained. The soil, in many places almost destitute of vegetation, is no doubt surcharged with this substance, and a portion of soil was collected to be analyzed, and

has been mislaid. In view of the difficulty experienced in obtaining this substance in time of war, the subject is well worth the attention of government.

Many of the earths and rocks were placed in the hands of my lamented friend and classmate, Professor J. W. Baily, for microscopic examination. His state of health did not permit him to go entirely through with the examination. He, however, had made some progress, and I here give a short and characteristic note from that eminent and beloved gentleman, which gives an interesting summary of the results of his investigations up to that time.

W. H. E.

WEST POINT, N. Y., *April* 2, 1856.

Major W. H. EMORY, *Commissioner U. S. M. Boundary Survey.*

DEAR MAJOR: This time we have some luck. Three of the specimens last sent prove quite interesting. They are Nos. 18 and 19, from cretaceous strata, Leon creek and Leon spring, West Texas, and No. 23, travertin-like crust, from bed of San Pedro.

The specimens Nos. 18 and 19 are interesting, as containing a considerable number of fossil Polythalamia, (microscopic calcareous shells,) and still more so from yielding fine *green sand* CASTS of the same minute forms. This fact of the occasional formation of green sand in the cavities of minute shells was discovered by Ehrenberg, and I have verified it in specimens from several American localities. I would be glad to get a good supply of Nos. 18 and 19 for further study.

The travertin-like crust, No. 23, has an organic basis. When treated with chloro-hydric acid, it leaves a spongy mass, greater than the original volume, and composed of plants belonging to the genera Oscillatoria, Hydrocoleum, &c. There are several of these plants which delight in calcareous waters, and always incrust themselves as in the specimens you have sent.

With regard to the moss agates, I cannot satisfy myself that the filamentous mosses in them are really of confervoid origin. If they were, it is now impossible to distinguish a single vegetable cell. I incline to the belief that they are rather concretionary deposits of oxide of iron, which may possibly have had organic nuclei to collect upon; but if so, these last have disappeared.

The cretaceous earths attached to the Texian fossils will be well worth further study, and any which have specks of green sand in them will be particularly interesting.

Yours, very truly,

J. W. BAILEY.

NEW YORK, 13 *Mercer street, January* 31, 1854.

Three samples forwarded for analysis:

No. 1. Silver ore from San Pedro mine.
No. 2. Ore from copper mines.
No. 3. Ore from Leona mines.

No. 1.—Argentiferous galena; partly granular, chiefly fibrous; specific gravity 603. It contains iron pyrites, disseminated in small cavities.

The amount of silver was determined by moist analysis. Two grammes of ore were treated with nitric acid; to the clear solution hydrochloric acid was added—the resulting cloride of silver fused. The lead was determined as carbonate, by adding carbonate of soda to the solution, after separating the silver. Some adhering earthy matters remained undissolved by the nitric acid.

Analysis yielded in 100 parts:

Insoluble silicates	4.50
Lead	82.20
Sulphur	12.79
Oxide of iron and traces of copper	.46
Silver	.03
Loss	.02
	100.00

Indicating a yield of 6¼ ounces of silver per ton.

No. 2. *Red copper ore.*—Massive; specific gravity 5.10; of a deep liver red color in fresh fractures, coated on the outside with a crust of green malachite, to the depth of $\frac{1}{10}$ of an inch; dissolved with slight effervescence in nitric acid; it fur-

nishes water when heated in the test-tube, arising from the presence of the hydrated carbonate. The copper was determined as oxide by treating the acid solution with caustic potass.

In 100 parts:

Water and carbonic acid	4.70
Oxide of copper	95.30
	100.00

or yielding $75\frac{36}{100}$ per cent. of copper.

No. 3. *Brown iron ore.*—Ochreous variety; specific gravity = 3; yields but little water in the tube; effervesces slightly in hydrochloric acid. The iron was determined as peroxide by precipitation with ammonia.

In 100 parts:

Organic (vegetable) matter and water	7.80
Insoluble earthy matter, (clay)	15.00
Peroxide of iron	70.70
Lime	5.05
Magnesia, Carbonic acid	1.00
	100.00

Yields 49 per cent. of metallic iron.

THOMAS ANTISELL, *M. D.*

SMITHSONIAN INSTITUTION, *Washington, March* 1, 1856.

SIR: I have the honor herewith to submit to you the results of the examination of salts, ores, and minerals, made by me for the United States Mexican Boundary Commission. The analyses were made in the laboratory of this institution. The numbers correspond with those attached to the original labels. The ores, though few in number, are of such a character as to raise high expectations of the mineral wealth which thorough exploration will develope in the region traversed by the commission.

No. 15. Argentiferous galena, from the copper mines of Santa Rita, in New Mexico. The specimens examined are very fine-grained galena, containing scattered particles and nodules of iron and copper pyrites, with some oxide of iron, resulting from the oxidation of iron pyrites. One of the specimens contains adherent portions of the gangue from both sides of the vein, showing it to have been, at this spot, 1 to $1\frac{1}{2}$ inch in thickness. It yielded 73.75 per cent. of lead. The mean of two accordant assays, by cupellation, gave 0.365 per cent. of silver. The copper in both this and the following specimen is so unequally disseminated, that it was impossible to obtain a fair average without destroying the specimen. The amount of copper in both ores is small.

No. 16. Lead ore, from the silver mines of San Pedro, in Chihuahua. The specimens furnished me do not, probably, represent fairly the richness of the mine. They are very unequal in composition and value, consisting of galena, mixed with zinc blende, quartz, iron pyrites, and a little copper pyrites. A sample, which was regarded as affording a tolerably fair average, yielded 28.29 per cent. of lead. The mean of two assays gave 0.70 per cent. of silver.

No. 18. A white saline substance, occurring as an incrustation on the soil, at Salado spring, in Chihuahua. It dissolves in water, leaving only a small residue of white sand, containing calcareous particles. It consists chiefly of chloride of sodium, (common salt,) with a considerable quantity of sulphate of soda, and small quantities of sulphate of magnesia, chloride of magnesium, and sulphate of lime. The presence of nitrates could not be detected. If this salt occurs in sufficient quantities, it will prove a very valuable source of supply of table salt, the want of which is strongly felt in this region. The presence of sulphates of soda and magnesia renders it unfit for use in its present state, but it might easily be freed from these impurities by solution and re-evaporation. The sulphate of lime is precipitated, in combination with sulphate of soda, as pan-stone, when the saline solution attains a certain degree of concentration. If the concentration be not carried too far, chloride of sodium crystallizes out almost pure. The mother liquor contains in solution the rest of the chloride of sodium, with sulphate of soda and salts of magnesia. It is highly probable that the springs which deposit this salt, by natural evaporation, contain, in solution, enough salt to be used as salines. The waters might be concentrated to a greater degree by being made to pass over piles of twigs, in graduation houses, as is commonly done in Germany. A great saving of fuel is thus effected. Analyses of the mineral waters of this country would probably lead to many important economic applications.

No. 18. Is merely the same salt as the last specimen, taken from a depth of six inches below the surface. The proportion of sand and gravel in it is much greater, but it shows that the whole soil is impregnated with saline matters.

No. 19. Copper ore, from Boca Grande, in Chihuahua. This is a very beautiful and pure specimen of red oxide of copper, intimately mixed with native copper. It is entirely free from sulphurets and earthy minerals. The exterior is partially covered with a thin crust of malachite—green carbonate of copper. This ore yielded, in an assay conducted in the moist way, 94.8 per cent. of copper. A very similar ore has been described by Mr. Blake, as occurring near Altar, in Sonora.* The compact subcrystalline appearance of this ore gives evidence of a massive deposit.

* United States Pacific Railroad Survey, (partial route in California,) under the command of Lieut. R. S. Williamson, Top. Eng., 1853. Preliminary report by William P. Blake, geologist and mineralogist, p. 75.

No. 23. A compact, white, feldspathic rock, from the valley of the San Pedro river, in Sonora. Before the blow-pipe it exhibits all the reactions of a felsite or fine-grained porphyry. The texture is compact, resembling the base of porphyry without the crystals. The surface exhibits numerous small cavities, resulting, perhaps, from the decomposition of crystals of feldspar.

No. 24. A yellowish pulverulent substance, described by Dr. C. B. R. Kennerly as occurring in a mountain gorge between abrupt walls of volcanic rock. When treated with acid it effervesces strongly, showing the presence of carbonate of lime. After the effervescence has ceased, the residue does not seem to be much acted upon by hot concentrated acids. Before the blow-pipe it fuses with difficulty to a white enamel, owing probably to a combination, at this high temperature, of the silica and lime present. Water takes up from it a considerable quantity of saline matters, consisting of sulphates of lime and magnesia, with traces of chloride of sodium and chloride of potassium. If this be a volcanic ash, as its appearance and mode of occurrence suggest, the presence of the saline matter and carbonate of lime must be attributed to the subsequent action of mineral, probably thermal, springs containing these salts in solution.

Very respectfully, yours,

JOHN D. EASTER,
Ph. D., Chemist and Mineralogist.

SMITHSONIAN INSTITUTION, *Washington, April* 11, 1856.

SIR: I have the honor herewith to report the result of my examination of the ores and coals submitted to me for analysis. Those the locality of which is not given belong to the collection obtained by you from a "prospecter," who refused to reveal the precise locality in which they were found. The rest were collected by Mr. A. Schott.

No. 1 is a lignite taken from cretaceous strata, covered by trap, at Santa Rosa, Coahuila. The specimen has a brilliant lustre, even fracture, and shows no trace of woody structure. The streak is brown. It is free from pyrites. Fragments of it heated to redness in a closely covered crucible lost 30.45 per cent. of water and bitumen, leaving 69.55 per cent. of coke, which was very porous and had a brilliant metallic lustre. The same specimen completely incinerated yielded 24.22 per cent. of ash.

No. 2. Lignite; a dull, lustreless specimen, otherwise quite similar to the preceding. Treated in the same way, it yielded 51.2 per cent. of coke, and 16.8 per cent. of ash, of a reddish color. No pyrites was observed in it.

No. 3. Lignite; in all respects similar to the preceding. It gave 45.5 per cent. of coke, and 15 per cent. of ash. This is the best of these coals. The great amount of ash which these specimens contain renders them of little value as fuel where wood can be had, but in the treeless region where they occur they may be very useful if the beds are extensive and occur at a small depth below the surface; as the specimens were probably taken from the outcrop, it is not unlikely that the seams, when further worked, will improve in quality.

No. 4. A lignite from Lake Guzman, in Chihuahua, containing a large proportion of iron pyrites, which, by the action of the atmosphere, has been decomposed and converted into sulphate of iron. It is entirely worthless.

No. 5. Water-worn pebbles of red oxide of iron, mixed with much silica, from Los Nogales, near the intersection of the parallel 31° 20′ north latitude, with the 111th meridian. The specimen which I assayed yielded 32 per cent. of iron; the assay was made by Penny's process, with bichromate of potash.

No. 6. Two small specimens of red hematite, mixed with specular iron ore and quartz, yielding 37 per cent. of iron.

No. 7. Carbonate of lead, associated with earthy black oxide of magnesia and iron ochre. This is a very unusual association of minerals. The magnesia contains no cobalt, as is the case in a similar ore occurring at Mine la Motte, in Missouri. The specimen yielded, in an assay conducted in the wet way, 17.04 per cent. of lead.

No. 8. Malachite, (carbonate of copper,) enclosing a core of red oxide of copper, containing a few particles of native copper. It yielded 67.76 per cent. of copper.

No. 9. Red oxide of copper, containing a considerable proportion of native copper, in threads and crystals. The specimen is created superficially with malachite, and is precisely similar to the ore No. 19, from Boca Grande, described in my former report. It will yield about 95 per cent. of copper.

No. 10. A specimen of black oxide of copper, associated with silicate of copper and silica. The mean of two assays gave 50 per cent. of copper.

No. 11. Black oxide of copper, mixed with some sulphuret of copper and quartz, from the Sierra Tule, in Sonora. This is very similar to the last specimen. It yielded 57.66 per cent. of copper. No silver was found in it.

No. 12. Red oxide of copper, associated with malachite and small particles of native copper, from the Arizona mines, in Sonora. The mean of two assays gave 74.96 per cent. of copper.

No. 13. A compact silicious ore, containing galena, sulphurets of copper, and arsenical pyrites, intimately mixed with quartz and calcareous spar. It yielded, in an assay conducted in the wet way, 41.84 per cent. of lead; 0.12 per cent. silver; and 2.8 per cent. copper.

No. 14. Galena, associated with variagated sulphuret of copper, carbonate of lead, and quartz. Very slight traces of silver were detected by hydrochloric acid. The specimen yielded 50.4 per cent. of lead, and 4 per cent. of copper.

I have the honor to remain, very respectfully, yours,

JOHN D. EASTER.

SMITHSONIAN INSTITUTION, *Washington, June* 2, 1856.

SIR: I have the honor to report herewith the results of my analysis of the mineral water brought by the Boundary Commission from Mier, and of a sedimentary deposit said to be taken from a spring in the same vicinity.

The water was contained in two bottles, obtained at different times, one by yourself, the other by Mr. A. Schott. The whole quantity not exceeding one quart, it was impossible to do more than determine the quantity of the more abundant ingredients and the presence of some others. A thorough and minute analysis of a mineral water cannot well be made with less than two to five gallons of water, some of the ingredients being present in exceedingly minute quantities, and yet, doubtless, exerting an important influence on its medicinal properties. The analysis was conducted essentially after Fresenius' method.

This water belongs to the class of neutral salines, the most abundant salt being chloride of sodium. Its specific gravity is 1.003.

A qualitative analysis proved the presence of the following substances: Silica, iron, alumina, lime, magnesia, soda, sulphuric acid, chlorine, phosphoric acid, iodine, and carbonic acid.

It is called a sulphur water, but I could not detect the presence of any trace of sulphuretted hydrogen. It has no reaction on test paper, and its taste is decidedly saline.

The result of the quantitative analysis is as follows:

The whole amount of solid matter is 0.6763 per cent., consisting of—

Silica	0.016586 per cent.
Protoxide iron	0.000754 per cent.
Alumina	traces.
Lime	0.009389 per cent.
Magnesia	0.009580 per cent.
Sodium	0.243323 per cent.
Chlorine	0.340470 per cent.
Sulphuric acid	.010180 per cent.
Phosphor. acid	traces.
Iodine	traces.
	0.630282

Combined in the following manner:

Silica	0.016586
Sulphate of lime	0.017306
Carbonate lime	0.004041
Carb. magnesia	0.020120
Carb. protoxide of iron	0.001214
Chloride of sodium	0.628560
	0.687827

The yellow powder (marked No. 25) is a deposit from a chalybeate spring. It was supposed from its color to contain a large quantity of sulphur, but this color is due to hydrated oxide of iron. When ignited, the mass assumed a bright red hue. No sulphur is present in it, but it contains considerable quantities of sulphates and chlorides of lime, magnesia, and soda.

I have the honor to remain, very respectfully, yours,

JOHN D. EASTER.

CHAPTER II.

SUBSTANCE OF THE SKETCH OF THE GEOLOGY OF THE LOWER RIO BRAVO DEL NORTE.

[By Arthur Schott, Assistant Surveyor, U. S. B. C., &c.]

SIR: In compliance with your instruction, I have the honor to submit to you the following description of the geological features of the country adjoining the Rio Bravo del Norte, from the mouth of the Rio Puerco (Pecos) to the Gulf of Mexico.

For the whole extent of country thus designated, I shall use the geological term *cretaceous basin of the Rio Bravo*, to correspond to the upper basin, which may be properly characterized as the *carboniferous metamorphic limestone*.

Banks of the Rio Bravo del Norte, 2-3 miles above the mouth of the Rio San Pedro, (Texas.)

Commencing at the point where the Pecos empties its muddy waters into the Rio Bravo, we find for a distance of about 50 miles a high table-land, consisting of solid masses of hard, dark-

gray limestone. This formation, viewed in its lithologic character, may be considered as carboniferous; yet the frequent occurrence of fossil remains within its limits hardly admits of its separation from the cretaceous system.

The outside of this limestone is, as already stated, of a dark ash color, often rough, prepresenting the appearance that a violently boiling mud-pool would after being upheaved and suddenly cooled. Its inside is often white or pale yellow, and mealy, with a great tendency to disintegration, which causes a great many holes, fissures, and excavations of every shape and description. These give this limestone a peculiar appearance, and one that is remarked by every traveller.

VALLEYS.

The small, as also the larger, valleys are mostly formed by the continued washing out of the dells and fissures. Thus formed by denudation throughout the whole country, with their borders cracked in every direction, they deserve only the name of deeply cut ravines, (cañons.) This cracked peculiarity may be ascribed to the combined influence of a high temperature, to which this formation may have been at some time exposed, and a subsequent more or less gradual refrigeration. There is scarcely a doubt but that all these table-lands were also formed under the sea, and at the same time exposed to volcanic action. If so, this limestone really deserves the name *metamorphic*, and its somewhat anomalous appearance would be accounted for.

It is our opinion that the limestone of the region above referred to is not of the same character throughout; it is not uniform, and appears under the most variable shapes. It may be seen in various localities, alternating with strata that bear the most striking resemblance to *magnesian limestone*.

STRATIFICATION.

The strata of this formation are generally arranged horizontally; sometimes, however, local disturbances appear which placed them into synclinal or anticlinal positions. The lower strata, often being of less solidity than the upper, and readily disintegrating under atmospheric agencies, are finally washed out into excavations by the action of water. These excavations occur commonly in the beds of ravines, and also in the banks of the river as considerable caves. They are also to be seen near the top of the table-lands and hill-ranges, lying as so many terraces, one above the other; the more solid layers, resisting the action of external agencies, project far beyond the softer.

High table-lands, intersected with deep vertically walled valleys, characterize the face of the whole country. The walls of these valleys, or more properly speaking, cañons, are variously cracked open, and presenting ravines of greater or less extent in all directions.

Those valleys seem to have relation only to the lithologic character of the formation. They are, therefore, usually short, and do not terminate in gradually diminishing fissures, like the heads of rivers and creeks, but suddenly end with a deep chasm under a vertical wall of rock. Deep holes are washed out under these masses of rock, where rain water collects and remains for a considerable time.

WATER HOLES.

Excavations similar to those here mentioned, and retaining water for some time, occur also in the usually dry beds of the tributaries of the Rio Bravo. This is in most cases the only water

that can be procured throughout the arid regions bordering the upper portion of the cretaceous basin of the river. Whilst the running water in these dry beds can find its way only by a subterranean passage through the holes and fissures presented by this formation, pools and small ponds of 150 to 200 feet in length and breadth occur in the cavities formed in the solid masses of rock. The valleys of the rivers Bravo, San Pedro or Devil's river, and Pecos, resemble each other in this respect.

BOTTOM-LAND.

Soil suitable for cultivation is scarcely seen in these river bottoms. When small slips of it appear, it is confined to places where a projecting rock or a deposit of mud and drift-wood offers some protection against the violence of the currents everywhere present in these rivers.

Such patches of bottom-land offer the only shelter and home for the growth of trees, consisting almost exclusively of live oak, hackberry, pecan tree, ash, and some two or three species of rhus. The country embraced by this formation is a waterless region, with a barren and rugged surface. There is but one constantly running tributary of the Rio Bravo between the mouths of the Pecos and San Pedro, a distance of 40 miles. The waters of this tributary, of a blue crystal-like transparency, boil out in a deep chasm from beneath a solid mass of limestone, and pour a rapid and full current into the river, but a few paces distant, through dark green shades of flowery and fragrant thickets that line its bed. Its solitary beauty, amid the barrenness and unbroken silence of the surrounding wilderness, suggested a fairy creation, and suggested the name of "Fairy Spring" to this enchanting stream.

Other ravines or "*rock creeks*" afford at times a small stream of clear running water. In their rocky beds occur here and there a series of water holes and small ponds, either isolated or connected only by a trickling run of water. There are several creeks of this character, especially in the vicinity of the Pecos; among which may be mentioned Painted Gallery, Nine-tailed Cat, Oak creek, and Fox-hole.

ANTEDILUVIAL DUNES.

Groups of hills and low ridges, from 80 to 100 feet in absolute height, appear in different localities on the table land of this region. Fossil remains are found on their slopes, and show that they also belong to the cretaceous formation, and constitute its last link. These hills may be considered as accumulations of cretaceous debris, preceding tertiary strata. The irregularity of the line of their direction, and their unmistakeable parallelism with the water-courses, lead to the conclusion that they really once bordered the submarine currents of a vast cretaceous sea, of which the section of country towards the mouth forms a part. Thus we are able to trace these antediluvial *dunes* on both sides of the river, and all its tributaries, not only in its upper part, but even as far down as the point where the cretaceous ridges come into view.

The Rio San Pedro forms a kind of geological boundary, and seems to have some close relation to other physical peculiarities of the adjoining region. Some changes are here perceptible in the fauna, flora, and meteorology; to speak of which, however, is foreign to the matter in hand.

UPPER METAMORPHIC LIMESTONE.

The limestone below the mouth of the San Pedro or Devil's river does not form such solid masses as that above. The high table-lands, already described, change into a more rolling,

sometimes broken, country. The rocky portions are only exposed along the valleys and water-courses, whose perpendicular walls, now thrown down, appear only as sloping banks. The lithologic nature of the rock becomes more earthy; its fracture, sharper. It, however, frequently presents a rounded and blunt surface, particularly where there is a tendency to disintegration. The limestone embraced in the section of country lying between the mouths of the rivers San Pedro and Las Moras, like that above, seems to be *metamorphic;* it, however, differs from the limestone above the river San Pedro, in indications of having been subjected to the action of a higher temperature; and its cretaceous character is also proved by the occurrence of fossil remains, which form in some respects a transition from the adjacent geological zone. The surface of this geological belt is completely covered with drift and alluvial soil; and the growth of trees (consisting almost exclusively of mezquite) appears more liberally distributed. Whilst there are scarcely any trees to be seen upon the prominent points, the dells, basins, or flat valleys, where rain-water washes together and deposits the more fertile portion of the soil, are usually invested with scattered groves of the leguminous trees.

HOW WATERED.

The surface of this region is usually dry; it is, however, well watered, when compared to the country adjacent.

The road from San Antonio to El Paso del Norte crosses in this belt (about 40 miles wide) six clear and bold running streams, of which Las Moras, Piedras Pintas, Zoquete, and San Felipe are the most characteristic. They are somewhat similar in general appearance, and in all probability have their origin on a more solid but in a greatly deeper situated stratum; for they pour forth at once their crystal waters either from deep funnel-shaped basins or from rocky clefts. Several of these springs indicate a higher temperature than the water in the streams below.

The water of all these little streams, as also that of the Rio San Pedro or Devil's river, is strongly impregnated with carbonate of lime. Everything hanging within its touch, or in any way exposed to its action, becomes perfectly coated over by its calcareous deposite in a remarkably short time.

In consequence of the permanence and abundance of running water in these tributaries of the Rio Bravo, their bottom-land will in time be highly valued for agricultural purposes. It would be an easy matter to irrigate it, as the fall of water almost throughout is very considerable.

INTERSPERSED STRATA.

The groups of hills mentioned before as placed upon the table-lands of the country between Devil's river and the Pecos, appear again in this belt as belonging not only to the later strata of the cretaceous system, but also apparently to a still later date. These strata are usually met with, bordering and constituting the edges of the different valleys. The fossils occurring in these localities are also of the age just mentioned. As an essential characteristic, we cite here strata and shoals consisting almost solely of entire and fragmentary pieces of *Exogyra*, *Arietina*, (Roemer.) They appear either in a state of perfect preservation, or as a real breccia; the cement of which is mostly an ochre-colored calcareous sand or clay.

The stratification of this formation shows a succession of layers of variously tinted marls, of more or less coarsely grained sand, and also of differently colored limestone; all are profusely

impregnated and sprinkled over with oxide of magnetic iron. Some of these strata contain pieces of the latter formed into every shape, but most commonly give to the matrix the real habitus of volitic texture.

This imbedded formation increases as you approach its lower edge, (Las Moras,) leading to another change in the lithological features of the country along the Rio Bravo.

Before considering this change, however, another fact of much geological importance is not to be overlooked.

THE DYKE.

About twenty miles below Las Moras is Elm creek, (Arroyo de Los Olmos,) the next tributary of the Rio Bravo on the Texan side. Its valley belongs to still another geological belt; none of the more solid metamorphic limestones before referred to are now to be seen. The whole country from Las Moras to the mouth of the Rio San Juan, and even as far down as the vicinity of the Mexican town of Reynosa, forms another link of the cretaceous system; a more soft and brittle sandstone, (partly chloritic?) varying in grain, color, and cohesion, constitutes the main part of this formation. This resembles very much, if it is not in reality, the green sandstone or chloritic chalk itself.

Its northern limit, where it joins the more recent metamorphic limestone some distance below the Las Moras, is distinctly marked by a line which shows on the surface or in the soil signs of a geological disturbance. This limit is the valley of Elm creek, two miles and a half above Eagle Pass. It is wide and flat; the ridges of hills bordering it are often overthrown and washed down, whilst the horizontal strata in many places are brought into synclinal or anticlinal positions. The creek itself, not the one of that name on the El Paso road, is sluggish, and carries only a dirty, greenish, and brackish water, which often disappears in its bed, leaving only here and there small ponds and muddy pools. Out-crop of pretty extensive beds of lignite coal occur on both sides of the mouth of this creek well worthy of examination, and may prove to be of commercial value.

These coal-layers probably gave the name "Piedras Negras" to the Mexican military colony in the vicinity. The aspect of the valley of Elm creek, and the character of the country to the right and left of the Rio Bravo at this point, justify the idea that a subterraneous volcanic dike crosses the basin of the Rio Bravo. By turning for a moment from our course along the Rio Bravo, and proceeding from the mouth of Elm creek in a direction southwest by south for about seventy miles, we reach the foot of a high and bold mountain range formed of metalliferous limestone, (*zechstein,*) the precious contents of which once made Santa Rosa famous as a silver-mining town.

On the line between the Rio Bravo and the Santa Rosa mountains, the face of the country shows many signs of a geological disturbance; the usually undulating region becomes more broken, whilst the flat, long-stretching ranges of hills are frequently overthrown. The slope of the Santa Rosa mountain is rocky, wildly broken, and steep, and large portions of the strata are entirely dislodged and most anomalously placed. The stratification here is not only seldom horizontal, but frequently thrown up vertically. There is some regularity, however, in this apparent disorder, particularly with respect to the parallelism—the characteristic of all the cordilleras of the American continent.

PARALLELISM AND VOLCANIC CROSS AXES OF THE MEXICAN CORDILLERAS.

By this parallelism is meant an inclination of the chief sierras to separate into collateral sub-sierras and side branches, which again join the main chain; or they are at least connected either by cross sierras, or even simple dykes. To this striking peculiarity the profiles of both the northern and southern portions of the western hemisphere are due. This mountain range of Santa Rosa presents another characteristic, and one, according to Alexander von Humboldt, peculiar to the mountain system of Mexico—it is, that the volcanic axes cross the direction of the Cordilleras almost always at right angles. There are many cross-valleys on the northeastern slope, proving the action of some volcanic disturbance; a valley some eight or nine miles east of Santa Rosa, called "El Potrero," is the most remarkable instance. Several mines are still worked here, where the metalliferous limestone is variously traversed by veins of feldspar and limestone spar; this latter usually accompanies the silver ore and galena. In the centre of this *cul de sac*, a better name for this so-called valley, can be seen an ancient crater, the inner walls of which are thickly coated over with a lava-like basalt of a dark red hue, whose composition differs apparently but little from that which covers in layers (20 or 30 feet thick) the cretaceous range of hills joining the northeastern slope of the metalliferous mountains.

It may, perhaps, be of importance to state that the argentiferous portion of the Sierra de Santa Rosa is not more than ten or eleven miles in length, commencing at a point called "El Cederal," (the Cedars, Cedar Grove,) and terminating at a place, in a northwest direction, bearing the name of "Los Nogales," (the Walnuts, Walnut Grove.) The presence of ores, together with the trap or basaltic dykes branching out from the sierra at right angles, may prove the supposition which places here the origin of the volcanic power, that, pushing through the fissures of stratified rocks, causes the dyke before alluded to. Following this dyke from Santa Rosa up towards the Rio Bravo, it will be found to cross the valley of this river in the vicinity of Elm creek, as already stated.

BASALTIC HILLS—VOLCANIC DYKES IN TEXAS.

On the Texan side, the first marks of volcanic action are to be seen at the head of Leona river. Here a solitary hill of 60 to 70 feet in height occurs, formed entirely of a dark green basalt which is closely allied to that of the Santa Rosa mountains, and which also contains much *hornblende* and *olivine*. In the vicinity of Fort Inge, and also near the head of Las Moras, are several hills of the same nature; also the road from Leona to the first crossing of Devil's river leads over several places indicating volcanic action.

The west bank of the Rio Frio, at the crossing, is formed of a solid mass of basaltic rock, which undoubtedly belongs to the dyke alluded to as having its origin in the Santa Rosa mountain, and here crossing the cretaceous formation.

DR. ROEMER'S VIEWS.

Dr. Roemer, in his not yet translated work, entitled "Die Kreidebildungvon Texas," ("The Cretaceous Formation of Texas,") mentions (page 8) that plutonic or volcanic rocks were brought to him from between the San Saba and Cibolo; and according to him, granite, together with older stratified rock, is seen in narrow strips, surrounded with cretaceous strata, between the

San Saba and Pedernales. Again, about fifteen miles due north of Fredericksburg isolated granitic rocks have been met with, among which is the "Enchanted rock," of popular renown.

Also, between the Llano and San Saba granite protrudes through cretaceous strata; and sixteen miles north of Fredericksburg occurs a coarse-grained granite, consisting of flesh-colored feldspar, gray quartz, and some little black mica.

In other places along the Llano very finely grained varieties of granite have been observed. Granite, frequently interspersed with veins and fragments of a white quartz, also appears at various points. Pieces of syenite, too, have been found along several of the tributaries of the Llano.

Besides these plutonic forms, trap-like rocks also seem to occur in many places of the country referred to by Dr. Roemer. Again, this author received from twenty miles to the northeast of San Antonio de Bexar pieces of a black basaltic rock, which protrudes in veins through the cretaceous limestone strata. In this basalt, as component parts, are many minute crystals of a white fossil, (glassy feldspar?) and also a dark, olivinish fossil.

The geographical distribution of the rocks of which Dr. Roemer speaks permits only the conclusion that all the marks of plutonic or volcanic formation must belong to the same system, which, traversing the upper limit of the more recent cretaceous strata in the valley of the Rio Bravo, shows itself in the shape of the low basaltic hills mentioned as occurring at the crossing of the Rio Frio, and at the heads of the rivers Leona and Las Moras.

There is no doubt that this dyke continues its northeastern direction, accompanying as an outlayer of the higher regions of the Guadalupe and Ozark mountains, and thus probably crosses the whole of Texas, and possibly Arkansas.

METEORIC IRON.

With regard to meteoric iron, to which Dr. Roëmer refers in connexion with the plutonic rocks, and of which he mentions a large specimen now preserved in Yale College, we have to state that, besides magnetic iron ore, which is scattered in loose innumerable pieces of every shape and size over the whole surface of the cretaceous basin of the Rio Bravo, meteoric iron is known to exist about ninety miles northwest of Santa Rosa. An American resident of this town, Dr. John Long, called my attention to a piece weighing some twenty-five pounds, which was then in the possession of a Mexican; small pieces had been cut from it, and hammered out without the aid of fire into some trifling articles. It is said that the whole surface of the area (embracing about thirty acres of land) where the deposition of this valuable mineral occurs is covered with blocks of it, of greater or less extent, some containing as much, and even more, than thirty-six cubic feet.

GREEN SAND WITH LIGNITE.

The upper limits of that portion of the cretaceous basin, which consists chiefly of strata of green sand, and the course of the volcanic dyke discussed above, seem rather to run parallel than approach each other.

So far as our observations extended, the main portion of the cretaceous basin, from Las Moras to the vicinity of Reynosa, forms a belt of 380 to 400 miles in width.

The upper part of this belt commences in the vicinity of Las Moras, and terminates some few miles above Laredo, a distance of about 200 miles, whilst the lower part begins where the former ends, and reaches as far as the vicinity of Reynosa, showing a width of about 340 miles. Both of these parts are distinctly characterized by strata of green sand, (chloritic chalk,) which change, according to the amount of oxyde of iron they contain, into variously tinted sandstone shoals. The solidity of the strata varies very much. They are sometimes formed into very solid rocks, well suited for mechanical or architectural operations; again, they consist of loose and coarsely-grained sandstone slate, which rapidly crumbles on exposure to the air. All these green sand strata are frequently intersected with layers of debris of analogous character.

In several places where these green sand strata were disintegrating, and being carried off by the action of the waters, there was observed a white, salty efflorescence, which may possibly be "ammonia." The "Rocky walls" near the mouth of the Arroyo Castaño, which is about 40 miles below Eagle Pass, and near the Presidio de San Juan el Bautista, are remarkable for this efflorescence, as also some terraces below this point. The frequent occurrence of a certain chenopodium, containing a large amount of this salt, and often covering exclusively wide tracts of sandy bottom-land along the Rio Bravo, may prove more conclusively the peculiar elements of the green sandstone.

The green sand, particularly in the upper belt, is often and variously intersected by strata of different nature, though certainly closely allied with the same system.

Strata of sandy or argillaceous marls, or blue or grayish clay, all profusely impregnated with oxide of iron, and even layers of corresponding debris, often intersect the green sand strata.

The general characteristic of this belt and its subdivisions is the strict horizontality of its strata throughout. It is only here and there that some slight local disturbance has taken place, as, for instance, near Laredo, and again some 40 or 50 miles above, where a dip of about 8° W.S.E. and E. is exposed.

The following peculiarities may serve to characterize the two subdivisions of the green sand belt:

LIGNITE COAL.

From Las Moras to the vicinity of Arroyo Sombreretillo, which is about 10 miles above Laredo, lignite coal occurs quite frequently. None came under our observation below this point; outcrops of it, however, are said to be found in the neighborhood of Roma, some 10 miles above the mouth of the Rio San Juan.

Though there is not much doubt of the existence of lignite below the Arroyo Sombreretillo, our observations have led us to the conclusion that it is more sparsely distributed.

These lignites vary both in appearance and quality; sometimes they are found to be scaly or slaty, and of a dull earthy fracture, sometimes resinous and sharply edged. Prints, and even remains, of plants, preserved in these coals, indicate vegetable forms of the higher orders, as gramineæ, (perhaps reed and cane,) and even parts of dicotyledonous trees, such as willow or ash. Other specimens of coal from below appear more amorphous; but it contains so much bitumen as to be of no use in the blacksmith's forge, where it runs together and becomes baked into a solid mass.

The localities remarkable for the most considerable deposits of lignite coal are the following:

On both sides of the mouth of Elm creek, near Eagle Pass, particularly on the north bank of this water-course, where layers from 3 to 4 feet thick are exposed. On the south bank of this

creek, also, and quite near Eagle Pass, several conspicuous layers are seen. A blacksmith, once connected with the garrison at Fort Duncan, used this coal for some time in his shop; and having satisfactorily tested its value as an article of trade, went to mining it. There was a ready market at San Antonio; the cost of the labor, however, in getting it out, together with the great expense of transportation on account of the Indians, put an end to the mining operations of this enterprising individual.

Small seams of coal appear also on the Mexican side of the river, just below the mouth of the Escondido, which is two and a half miles below Eagle Pass.

The thickest layers of coal noticed, however, are on the slope of the Lizard hills, below the deserted rancho Palafox; a more bituminous coal occurs here in layers from 4 to 5 feet thick.

According to our experience, the finest and best of all the lignite coal in the valley of the Rio Bravo is that which occurs in the neighborhood of Arroyo Sombreretillo. This is apparently the most bituminous observed on the whole line.

Off from the river, near Santa Rosa, lignite coal was seen. Although its layers are thinner, and its quality inferior to the various deposits heretofore alluded to, yet its relation to and close connexion with them hardly admits of a doubt. The layers, generally horizontal, are here thrown up almost vertically; which position is the natural consequence of their being placed near the basaltic dyke frequently referred to before.

BITUMEN.

It is but proper to mention here the occurrence of another fossil, not less interesting and valuable than coal. This is a sort of fossil resin or bitumen, which was met with in loose scattered strings on the slope of "White Bluffs," about 20 miles below Eagle Pass. Some few and but small specimens (such as could be saved) were sent to Dr. John Torrey for examination, who found them to be similar to a substance which he had received some time previous from the province of New Brunswick, and examined in order to elucidate a law-suit there pending. Can it be that the occurrence of this fossil in these extreme cretaceous localities proves a close relationship between their respective strata?

BLUE OOLITE-LIKE LIMESTONE.

Other intermittent strata of the upper green sand belt may also be considered as characteristics. For instance, there appears frequently a blue coarsely-grained limestone of a decided oolitic texture, often showing a somewhat crystalline and sharp fracture. This is sometimes alternately intersected by and covered with an ochre-colored stratum, usually of a more sandy structure. Both of these rocks abound in fossil shells of a more recent cretaceous, if not of tertiary age. They cannot, for this reason, be pronounced as truly oolitic, however much their structure and appearance might justify such a supposition. Wherever this limestone occurs, it affords to the inhabitants the material for building their houses, and is also burnt in kilns for domestic use. May it possibly be identical with the "Calcaire grossoir" of the French? Some strata of this limestone show large masses of a compound, consisting either of magnetic iron combined with sand and marl, or clay, or an aggregation of the latter strongly impregnated with the former.

BLUE CLAY.

Besides this limestone, there are strata of a dark gray, sometimes blue, clay, which either cover or intersect the layers of green sand. This clay is often hard and rock-like, forming sometimes extensive reefs and banks, which seriously obstruct the navigation of the Rio Bravo. In other places, especially where it is under water, it is soft, and can be moulded between the fingers like plastic clay, to which it is closely allied, if not identical with it. The renowned rapids of the "Isletas," in the vicinity of the Mexican Presidio San Juan El Bautista, are formed by this clay. Above this place, some 10 miles, are similar clay deposits covered with shoals of oyster-breccia 2 feet thick, pieces of which were added to our collection of fossil specimens.

A clay similar to this usually accompanies the lignite coal that has been referred to above.

These are, then, the characteristics in which the upper portion of the green sand belt differs from the lower, where alternating strata of sandier compounds prevail, instead of the argillaceous, as in the former.

THE GREEN SAND WITH FOSSIL OYSTERS AND SHELLS.

As the frequent occurrence of lignite coal characterizes the upper belt of green sand, so the banks and shoals of fossil oysters indicate the lower.

These oysters, together with conglomerated shoals of shells, seem to be of an age still later than the fossils of the cretaceous period above; some, indeed, would seem to belong properly to the tertiary strata.

The lower portion of this green sand belt appears generally as if it were constituted a part of the eocene system.

The prints and remains of dicotyledonous and monocotyledonous leaves and plants in the lignite coal, with some fossil shells of later age, led to the conclusion that all such fossiliferous strata belong to the tertiary period, which, however, seem to have only a local distribution throughout.

In this belt tertiary deposits occur very generally, sometimes constituting extensive tracts of land.

The fossil oysters and shells before spoken of are of the largest size; and extensive banks of them are seen at several places along that part of the river embraced by the lower green sandstone belt. Of these, we may instance Roma, the Island Las Ajuntas, Shady Bluffs, near Mier, and a point some 25 to 30 miles above the mouth of the San Juan. Other similar fossils are often found at these places covered with a perfectly chalky-white coat.

Slate-like sandstone often intersects the green sand, and forms at a number of points massive walls of considerable extent; the adhesive quality of the particles of this rock, however, is often not very persistent. Its inside is very soft and readily crumbles, as is shown sometimes by the disintegration of the outer coat.

SEPTARIAE.

Another peculiarity of this lower belt is the frequent occurrence of a variety of septariae. The highest place in the valley where they were seen (probably only as drift) was between Elm creek and Las Moras. Further down the valley, however, they are more abundant, and just

below the mouth of Arroyo Sombreretillo they make their appearance quite frequently. Again below this point they are still more plentiful. On the oyster-terraces, some forty miles below Laredo and near the Rancho San Ignacio, there is a spot remarkable for the abundance of this fossil; as are also the following places: the slope of "Red Ridge," of "Shady Bluffs," and Septariae Hills. Their most common shape resembles very much a small, flat loaf of bread. Both on the out and inside large irregularly-shaped divisions, like cob-webs, are to be seen, which seem to have been formed by a net-work of veins composed perhaps of crystals of gypsum, which commonly abounds here. This fossil is in all probability to be referred to ludus helmontii, (turtle stones.)

The largest septariae of this kind was seen at Laredo, whither it was brought from the vicinity of the Arroyo Sombreretillo. The whole piece, 2 feet across and nearly 1 foot thick, consisted only of the cob-webbed part, showing cellular aggregations of a silicious matter; its color was pale yellow.

"The Bombshell Bluff," on the lower Rio Bravo del Norte, Texas.

Fragments of similar septariae, if these latter deserve that name, were also found in several other localities below Laredo. Other aggregations, septariae-like in character, are seen as balls or nodules of various sizes, composed of a pale green sand imbedded in a similar but more brittle marly matrix. Clusters of such balls abound under some green sand bluffs near Rancho Clareño; from the size of a three-pound cannon shot up to that of the largest bombshell—sometimes entire, sometimes cracked in two. So striking and peculiar are these rocks, as to be justly entitled to the name of "Bombshell Bluff," with which they were christened.

FOSSIL BONE.

The lower portion of the green sand belt reaches as far down as the vicinity of Reynosa, which is about 200 miles from the Gulf. Here the last cretaceous ridge of hills approaches the valley of the Rio Bravo, though no rocks are exposed on its banks.

Tertiary strata seem, however, to occur alternately throughout the whole country. Many bluffs and ridges may be referred to this formation; for a fossil bone was taken out of a bluff near Camargo, on the Rio San Juan, and was in the possession of a resident of Eagle Pass, who stated that many such interesting remains of fossil fauna were to be found in the same and similar localities.

FOSSIL WOOD.

As to the presence of tertiary strata in the valley of the Rio Bravo, it would be proper to add here another suggestion based upon the frequent occurrence of fossil wood; by a close examination of which. some three or four genera or species might be classified.

The mouth of Elm creek is particularly distinguished for the abundance of fossil wood, which is usually found here scattered about as if brought down from some higher localities; yet pieces of trunk and branch sometimes were so arranged as to lead one to suppose that they once belonged to a tree on the spot, which had just fallen to the ground. Not far from this place, and very near the layers of lignite coal before spoken of as lying adjacent to Eagle Pass, the trunk of a fossil tree was discovered in one of the innumerable ravines cutting the borders of the Rio Bravo valley, 2½ feet in length by 15 inches in diameter. The largest pieces of fossil wood, however, were noticed in the environs of Santa Rosa; it abounds especially at the foot of the table-land ridges, running out in a northerly direction from the main ridge of the argentiferous mountains. These flat ridges, called by the inhabitants "Las Mesas" or "Lomas," belong to the cretaceous system, and are covered with strata, from 20 to 30 feet thick, of basaltic rock and trap or basaltic tuff.

So far as could be seen with the naked eye, there is not much difference between the texture of this fossil wood and of that near Eagle Pass and at other places along the valley of the Rio Bravo. Most of this fossil wood possesses apparently the structure of the palm-wood. The color of the specimens from Santa Rosa, however, is quite different from the rest. They show a dark reddish brown, much like the basalt in their neighborhood, placed on the top of the mesas. It seems highly probable that this wood may have been at some time in contact with these igneous and eruptive rocks, and that this red brown color was imparted to it by a certain proportion of oxide of iron.

The larger pieces of this fossil wood have been carried to town to serve as corner-stones. Some of these measured from 3 to 3½ feet in length by from 12 to 18 inches in diameter. The large size of the Santa Rosa specimens, compared with those found in the valley of the Rio Bravo and the surrounding country, led us to conclude that the former were not brought from so great a distance as the latter; in fact the former could not have originated far off, because the tertiary strata, which are undoubtedly their home, cannot be sought for on the top of the Santa Rosa mountains, bordering as these do the cretaceous basin of the Rio Bravo.

Whether all the fossil woods of the various localities mentioned are endogenous or not, we are

not prepared to state; though we think it is possible that some of it may be correctly referred to the coniferae.

This fossil wood belongs to both of the subdivisions of the green sand belt, and may be ascribed to them as a geological characteristic; it occurs more frequently, however, in the upper portion. It is not only to be found in low places, in the bottom, and on the borders of valleys, but also in the midst of the elevated and vast prairies that stretch from one water-course to another. It here lies scattered broadcast among the pebbles of the diluvial drift that covers all the plains and slopes.

PHYSICAL FEATURES OF THE COUNTRY.

The section of country embraced by the green sand belt, though somewhat similar in its outlines to the table-lands of the cretaceous limestone above, presents a more gently undulating surface. Although the upper side of this belt shows the horizontal stratification of the cretaceous system, yet, being interspersed with ranges of hills and ridges of a later age, (and even of tertiary origin,) the land as a consequence becomes more rolling. The substrata of limestone which constitute the beds of the clear water streams between Las Moras and San Felipe being placed much deeper in the lower country, and probably out of contact with the subterranean strata of metamorphic rocks belonging to the volcanic dyke of the country, may account for the general dryness of the green sand region; for this seems to be entirely deprived of running streams, as elsewhere stated.

The dry water-courses, sometimes cut from 50 to 80 feet deep, show only at distant intervals pools or ponds. These reservoirs contain a dirty, green, brackish water, on which man with the wild and domestic animals alike have to depend. This water benefits but little the surrounding soil, which affords at most only a scant vegetation. Narrow and limited strips only, bordering on the immediate edges of these ponds, flourish with the vegetation of a well watered soil. These water-holes, though, bad as they are, are real oases in this desert region, and afford the only meeting places of animal life; here, the white man, a traveller, and for the most part peaceable in his pursuits, the Indian, more or less hostile to civilization and humanity, and the herd-driving, half-breed Mexican, seek this indispensable gift of nature.

Such places are easily recognized, even at a considerable distance, by the presence of numerous and various flocks of birds, and a nearer approach shows them to be marked with a denser growth of trees, shrubs, and weeds. They constitute a distinct characteristic of these regions.

Between the densely covered borders of these watering places and the bare slopes and arid heights, dells, basins, and all other varied depressions, almost always exhibit a more luxuriant state of vegetable life. This condition may be explained in part by the increased hygrometric capacity of the atmosphere, however little moisture may be deposited. Here, also, the rain-water sweeps together the more fertile particles of the soil, which, possessing a great deal of moisture, comparatively, causes vegetation to spring forth. In this same belt of country, on the Mexican side of the river, there are more running streams than on the Texan side; and for the reason that the conditions on which their origin and existence depend, are less distant, as will be made evident from what follows.

Sierras or mountain ranges, formed of igneous and metamorphic stratified and unstratified rocks border, on the Mexican side, the cretaceous basin of the Rio Bravo. To these that side of the river is indebted for running water in the shape of several large, clear-water streams. Where there is hardly one running stream on the Texan side, on the Mexican are six, which carry no inconsiderable quantity of water in the Rio Bravo.

Besides the small streams, very changeable in their supply of water, the following are remarkable for their constant flow:

Escondido, near the head of which is situated the town of San Fernando, has its mouth about three miles below Eagle Pass.

Las Cavezeras, heading in the immediate vicinity of the Escondido, with the little town of San Juan de Allende and Nava near its source, empties some thirty miles above the destroyed rancho Palafox.

The Salado, carrying what may be considered here a large body of water, which is supplied by several large branches from near Santa Rosa, (Sabine, Alamo, and others,) commingles its waters with the Rio Bravo some eight miles below Guerrero, and nearly opposite Redmond's rancho.

Alamo, having its source in, and bringing its waters down from, a more southern portion of the Mexican Sierra, falls into the Rio Bravo near Mier.

The San Juan, gathering its waters in still more southern portions of the Sierras which form the highlands of the States of Coahuila and Nueva Leon, empties just below Camargo.

There is almost no running water on the Texan side from the beginning of the green sand belt down to the mouth of the Rio Bravo, if we except some few sluggish, half-underground, trickling creeks. If it were not, however, for their subterranean course, which prevents entire evaporation, this region would be wholly destitute of water.

The state of water near the mouth of these creeks is always affected by the rise or fall of the river, and also by the hygrometric precipitation of the atmosphere, however small quantities this latter may contribute.

These peculiar water-courses form a characteristic feature of the country through which they run; and their thorough knowledge gives advantages to the natives, by which they elude the pursuit of the white man, and render his efforts of no avail.

THE ISLANDS.

Another peculiarity of the portion of the Rio Bravo that winds through these cretaceous regions is the frequent occurrence of islands, various in size and appearance.

Whilst in the upper part of this cretaceous main the size of the islands is reduced to that of mere bars and reefs, (bare, or covered with rush and cane,) further below their absolute height above the water increases, and consequently the number of vegetable forms growing upon them.

As nearly all the islands are formed by alluvial deposits on stratified rocks, the layers of which they are composed assume or are arranged in a strictly horizontal position. As a matter of course, therefore, the down-river end usually rises high above the water, while the up-river end always appears partially covered with muddy and gravelly deposits and driftwood and the like that the river is continually carrying down.

Above, the islands are only mere banks or mud-bars, brought in by the tributaries and deposited according to the action of the currents of the river. Where the current is rapid and the course of the tributary is short, as is the case between the Las Moras and San Pedro, islands are not formed in the middle of the river; here they occur only as long narrow stripes of half immersed bars and banks below or above the mouth of the tributary that causes them. Sometimes the force of the river keeps back the deposit, and causes the formation of the island within the mouth of the tributary; such a case is presented at the mouth of the Arroyo "Piedras Pintas."

Where the water is sluggish in the river and a strong current in the tributary, the islands are pushed further out from the mouth of the latter.

Islands, rising to the height of the alluvial banks of the river, 20 to 30 feet above the water, do not occur above Eagle Pass.

Cazneau's Island, named in honor of an American gentleman who resided in this vicinity for several years and cultivated it to some extent, is the first that is situated above the common high-water marks Such, however, are rare between Eagle Pass and Laredo, and it is not until reaching a point some ten miles above the latter place that another island occurs which would be worthy of consideration for agricultural purposes.

Below Laredo, the first island of this kind is "Isla de los Rancheros." With this commences a series of about twelve, which the Mexicans cultivate, raising corn, tobacco, melons, pumpkins, and other produce for domestic use.

To facilitate the identification of these islands, the following names were given to them in the topography of the survey: Mustang Island, Belvidere, Maj. Brown Island, Carriso, Melon, Green Tassel, Patriarch, Cypress, Island of Last Rocks, Isla Los Ajuntas, Beaver, Sabine, and Green Key; the latter one being only a narrow flat strip, subject to inundations, ought rather to be classified with the islands of the upper region.

Among the islands here mentioned, Los Ajuntas, near Mier, is, in consequence of its size and fertility, the most valuable. It is also the largest one of all, being 2½ miles in length by almost ¾ of a mile wide; its upper part is heavily timbered, whilst its lower is open, and constantly under cultivation.

At the mouth of the Salado, and thence downward, the shore and banks of the Rio Bravo are of a softer character; the former is more muddy and sometimes miry, while the latter, disintegrating and washing down, lay the foundation for, and causes an increased growth of, vegetation. The soft soil, with the luxuriant undergrowth, added much to the labors of our surveying party.

At the Island of the Last Rocks, shoals and reefs, obstructing the navigation, make their appearance for the last time in the bed of the river, though rocks are still seen on both sides along the shore. If rocks do appear in the bed of the river further down, no danger is to be apprehanded from them because of their depth below the surface.

The lower part of the green sand belt undergoes still another change in its external appearance; this is quite perceptible at the mouth of the Rio Salado, and downwards continuously from that point. The frequent occurrence of oyster banks and shoals, together with the external appearance of the strata, seem to verify the inference that the regions here and below are of a still later age than the green sandstone belt.

The Rio Alamo seems also to indicate a distinct line in the geological features of the country.

Besides the presence of extensive fossil oyster-banks in its vicinity, there is below its mouth, on the Mexican side, a most rugged and naked spot, which presents the appearance of having just been torn to pieces by some destructive freak of nature. The scene of this apparent catastrophe now constitutes a wide flat basin, which is arid and literally cut up in every direction by ravines and rills. On the borders of these ravines, which run to a common centre and form a pool of water known as the "Sulphur Spring," are to be found a sulphur-colored earth, probably alumn and sulphur. The mineral water of this spring just now under examination tastes strongly of sulphurated hydrogen gas, and after standing for some hours in a vessel, collects a black deposit on the bottom. This water is celebrated in the country around for its medicinal properties. When the American army was camped near here during the Mexican war, it was much used on the recommendation of the surgeons.

Here, within a distance of about 2½ miles, several water-courses empty into the Rio Bravo, and form by their deposits a large island, which, as a result of this united action, was named "Los Ajuntas;" besides the Alamo, already mentioned, these tributaries are the Sulphur Spring, the Saladito, and Arroyo Hondo.

THE FLORA.

The flora of both the green sand belts show, as to the number of genera and species, various additions, and a more luxuriant development when compared with the vegetable life of the regions above.

As instances, the Huisache and Guaxillo, and other plants, all of the Mimosa family, growing above only as arborescents, gradually rise in these belts, and further down in the valley, to the size of conspicuous trees, often forming dense copses in the old beds and on the banks of the river. Of the several genera added, especially noticeable, are the Coma tree, the Nacavites, the Anacua, and Sabina; the latter two seem to have been brought in by the Rio Salado.

The appearance of the Cypress (Taxodium) Sabina of the Mexicans makes quite a striking change in the physiognomy of the country. This water and rock-loving tree often appears right in the middle of the swiftest currents of the river, where having taken hold of some rocks on the bottom, it boldly defies the force and action of the water. These cypresses on the Rio Bravo, commencing at the mouth of the Salado, extend as far down as Beaver Islands, just below Roma, where they make their last appearance in the channel on the Mexican side, footing in water from 14 to 15 feet in depth.

THE COLLUVIAL BELT.

After passing the lower green sand belt, (geographically speaking,) which has its lowest limits in the vicinity of Reynosa, as already stated, the colluvial commences and extends down to the coast. Under the term "colluvial" we include both the diluvial and alluvial deposits; these are irregularly and somewhat alternately arranged—the result of the oscillatory action of the salt waters from the sea-side, and the antagonistic and downward force of the fresh waters.

It is on account of this irregular distribution that the colluvial belt cannot be properly subdivided into a diluvial and an alluvial portion. Topography and, in some degree, botany, may, however, aid in examining, in its subdivisions, this lowest belt of the cretaceous basin of the Rio Bravo.

From Reynosa to the Rancho Lomita, 18 miles above the mouth of the river, the surface of the country is of a gently undulating character, which is accounted for in the fact that the colluvial deposits rest upon underlying cretaceous strata, which become deeper and deeper as the coast is approached. The river is now more serpentine in its course, and at almost every one of its numerous bends may be seen a lagoon, pond, or pool, in which thousands of water-fowl collect and feed. There is little or no tendency in the river to form islands towards its mouth, where it becomes narrower; its bed, however, is always undergoing constant and rapid changes. No bend, under the capricious action of eddies and whirlpools, retains its form for more than a season.

We noticed at several points, where a new bed had been formed a short time before, that there was scarcely any perceptible difference in the strength of the two channels, the river taking its course through both with equal force and volume. The boatmen not unfrequently found themselves in a sort of "steering dilemma" at such places, not knowing which was the channel. The outlet of the old bed, or its junction with the new, presented quite another aspect, and certainly not inviting entrance to those who come *up*.

It is in this region that the vegetation of the Rio Bravo displays its highest and most luxuriant development.

All the bottom-land, not under cultivation and not subject to the action of the water, is covered with dense thickets, almost wholly impenetrable, composed, as they are, of lofty trees as well as of smaller undergrowth, and of a great variety of creepers and vines, springing up from every spot not otherwise occupied, and filling up all the open and shady spaces, from the foot to the topmost branch of every tree and bush. It is also in the lower portion of this belt (where the Palm tribe is represented by the Chamaerops Palmetto) that the Palmetto attains a growth as gorgeous even as that on the Lower Mississippi; it extends on the Rio Bravo up to about 80 miles from the Gulf. In addition to the Palmetto common to the lower portions of these two great rivers, the constant appearance of a Tillandsia (Spanish moss) depending from the branches of the trees in long clusters increases the similarity of their scenery. Whilst the existence of this moss proves a higher degree of atmospheric moisture here than in the country above, the occurrence of the Palmetto may indicate the vicinity of the sea.

There would, perhaps, be no mistake in placing the limits of the maritime belt where the growth of the Palmetto ceases, particularly if we take into consideration the fact that several salt-water loving plants keep company with this representative of the Palms. The real coast belt, however, in the true sense of the word, may be placed with more propriety in the vicinity of the Rancho Lomita, 18 miles above the mouth of the river.

THE COAST.

Lomita, the diminutive of Loma, a long, somewhat flat hill or ridge, forms one of the last topographical monuments on the Rio Bravo. These consist of a low ridge of calcareous clay, bare and almost entirely deprived of any vegetation whatever. The ridge on which the town of Lomita is situated, like several others below, shows marks of being continually under the destructive action of the tide of the sea and flood of the river which meet here.

From Lomita down the land shows the real character of the seacoast, the vegetation decreasing gradually towards the mouth of the river. Most of the trees here yield the field almost solely

to some few members of the Mimosa family, of which latter the Huisache maintains its place nearly down to the tidal sand-banks of the gulf.

Lagoons, old river beds, ponds, swamps, pools, bayous, and other similar phenomena now constitute the lowest belt. Here the deceptive mirage constantly bounds the distant horizon, and the scenery, under its influence, presents to the mind but a chaotic dream still hovering over the land—a twilight gift of creation.

Besides the regularly occurring ebb and flow of the tide, which was observed at Rancho Lomita varying from about four to six inches, the fauna of the water indicate that the maritime belt has its upper limits in this vicinity. Some little distance below Lomita a two-valved shell and a decapoda, the camaron of the Mexicans, announce the proximity of the sea. Both of these animal forms seem to go up as high through the alluvial deposit as the tide affects the river.

ALLUVIAL DEVELOPMENT.

There is another portion of this lowest and most recent formation which, still under the continual action of both salt and fresh water, might be considered only as a rudimentary development of the alluvial belt along the coast. Not having yet risen above the level of the water, it is called, in the language of the sailors and pilots, the "bar." Such a place affords a home only for the various marine crustaceæ, and the meeting ground of the sea-fowls, the wreckers of the population of the air.

In regard to the topographical features of the coast, it may be completely characterized by the statement that it consists partly of the fragments of the solid parts of marine animals, partly of entire or decomposed vegetable forms, partly of deposits of inorganic matter, and partly also of fragments of animals, vegetable matter, and other material brought down by the river. Washed off and brought back again by the varied motions of the waves—sometimes united, sometimes antagonistic—as a matter of course this adjunct of the colluvial belt is always undergoing a change. This is, however, strictly regulated by the varying amount of power exercised on the one hand by the irresistible waves, and on the other hand at times by the no less forcible flood of fresh water. Agents of the sea are atmospheric currents and ebb and flow of tide; antagonistic to these oscillatory movements are the forces of the river, influenced by the hygrometric conditions of the air and the hyetographic state of the seasons in the country above and along the river.

The bar, though a mere toy under the action of the forces just mentioned, is not to be overlooked, for it is a constantly increasing piece of land not yet left by the working hand of creating nature, and therefore a matter for observation of much interest.

The muddy sheet of river water covers the whole view seaward before its mouth, when there is not any wind or current setting against the natural flow of fresh water; but if south or north winds are prevailing, the muddy tribute of the Rio Bravo, instead of spreading out into the open sea, and commingling there undisturbed with the salt waters, is checked and pressed aside as a long narrow strip along the beach in the direction that the wind sets the current.

Considering these circumstances, it is therefore clear that the place of deposits, both of the sea and river, gathering about the mouth are kept in a continual and also somewhat regular motion.

Among the regular changes to which the bar is subject, the most important is that caused by the annual rising of the river, which occurs during the months of July, August, and September. By means of this increased fresh-water power the deposits are carried and kept further out at sea, perhaps as much as a mile from the mouth. During the rest of the year the bar again approaches the beach; the oscillatory action of the salt water prevailing for this time, it is scarcely half a mile off the mouth of the river. The hydrographical distances between the bar and the mouth may be found on map No. 1, in the archives of the Department of the Interior.

Besides these regular changes, others occur monthly and daily that depend on the prevailing winds from the seaside, or meteorologic influences of the country above, not including many accidental occurrences which usually escape the scrutiny of the common observers. Of the latter kind are the depositions of drift-wood, or even wrecks and pieces of timber, which, after being washed ashore and left for awhile, are apt to form the foundation of a small bank or bar. Other more perceptible causes are seen in the stormy weather raging upon the sea and in the hurricanes on land.

These agencies, incessantly at work, all tend to one result, no matter how different their form of action may be, that is, addition to the land. The ebb and flow of the tide, the current of the river and sea, though often acting in opposite directions, only collect and again distribute the various material brought together by both fresh and salt water along the beach, where is presented by these gradual accessions the now forming and youngest portion of the continent.

The operations of all these forces may be altered or varied by extraordinary influences that may occur at any time, as they have done in ages past, such as the change of river beds in the alluvial regions, the closing of the mouths of the river, and the opening of other outlets.

There is not much doubt that the Rio Bravo once had its main mouth far from its present locality, no matter how powerful the descent of its waters to the sea must have been in all time.

Boca Chica, as its name implies, may be considered, without question, as one of the outlets of the Rio Bravo, which has thus contributed to the formation of Brazos Santiago and Point Isabel.

The currents over the bar of Brazos Santiago pour in a channel of such force against the tide as to corroborate the inference that a still greater fresh water flow than that of the Arroyo Colorado, some 25 miles to the north, comes into this bay. A glance at the course of the lowest portion of the Rio Bravo leads to a similar conclusion, for it has a decided inclination to the northeast after reaching the lowest portion of the colluvial belt.

It may be that the persons who attempted several years ago to dig a canal from the third bend (above its mouth) of the river, towards Boca Chica, or Brazos Santiago, may have had similar ideas on this subject.

We have thus dwelt almost two long on the formation of the bar; but however inconsiderable this matter may appear, it is still highly important to know the agents by which restless nature is achieving its work, the more so as the very same powers, now augmenting the land from the seaside, have, in all human probability, been contributing to this end for ages. It really seems beyond question that these oscillatory motions of the waters with the sweep of the gulf stream have deposited during the various ages of the cretaceous and perhaps tertiary sea that sediment along the foot of the bold Sierras, which at the present day form the western and northern limits of the now cretaceous basin of the lower Rio Bravo.

Taking also into consideration the parallelism of the easternmost of the Sierras of Mexico and

the sinuosities of the Gulf Coast, there cannot be any mistake as to the relation of the one to the other. The various cretaceous terraces of the lower Rio Bravo basin, placed, as they are, one above the other, appear in this position as so many antediluvial tide-marks of that vast sea; on the bottom of which secondary and also tertiary formations have been deposited, together with all those fossil types of organic forms—each genus and species belonging to its respective geological day.

Like the tide-marks that are arranged in large concentric circles, and that have been brought about by the oscillatory motions of the waters, the organic remains (leaves in the mighty book of the history of creation) can tell each one a tale of the physiographic condition of the age during which it rejoiced in the functions of life.

Whilst the currents and other forces of the water, acting horizontally, placed the different strata along the foot of the ancient coast of that *secondary sea*, a vertical force was needed to bring the submarine strata above the level of the water. If there were no signs of such a power, we could be content in believing that since the formation of the submarine strata the salt water has receded. There is evidence, however, that does not admit any question of the upheaval of the country. The volcanic dyke before spoken of is the strongest evidence in favor of this conclusion; these basaltic strata projecting through the cretaceous, and generally, also, a part of the older secondary formation, have caused a rise in the whole of the cretaceous system. Thus the peaks and branches of this dyke naturally became the *caryatida* of the great geological edifice of this country, often bearing detached portions of the cretaceous strata far above their general level.

GENERAL VIEW OF ORGANIC REMAINS.

With regard to the fossil remains of the regions of the lower Rio Bravo, which have come to our knowledge, there are many among them common to the cretaceous formation of New Jersey. With this locality they are also quite synchronous, according to Mr. Conrad, who has examined them. The specimens of this character are mentioned in his enumeration of genera and species. Many of these fossil remains, however, seem to belong solely to the cretaceous formation of Texas, and are more particularly referable to the southern portion of the secondary strata, which, on their part, are also nearly allied to analogous forms of the cretaceous formation of southern Europe, especially that part lying about the Mediterranean.

To go here more into the details of this supposed relationship between the southern and northern cretaceous formations of both hemispheres is not the design of these pages. To such of our readers, therefore, that may be desirous of examining this matter further,* we would refer them to Dr. Roemer's work, already mentioned, which contains well-founded hints and proofs on the subject.

Besides the before mentioned interesting specimens, so important to the knowledge of the general distribution of fossil forms, several new species have come to hand which seem to be indigenous to the cretaceous formation of Western Texas. The enumeration by Mr. Conrad shows, so far, six new species. Since then, however, another set of organic remains has been sent on for examination; and it seems to be not improbable that still other new forms may be met with in this collection of ours, the second made on the lower Rio Bravo. It is probable that some of the specimens of this last set will prove the prevalence of fossils of the tertiary system, which may

* For a full exposition of this subject, see Dr. Hall's report, which concludes the Geology of the Boundary.

be more developed in the lower portion of the lower green sand belt. This, however, is a mere suggestion to point only to the regions where data may be sought for; by means of which the distribution and limits of an eocene, and, perhaps, even pleistocene formation could be recognized.

We had not the opportunity to make such an investigation. It therefore devolves on some other person to continue the researches necessary to a complete understanding of the subject, and to the advancement of science in general.

CHAPTER III.

GEOLOGICAL FEATURES OF THE RIO GRANDE VALLEY FROM EL PASO TO THE MOUTH OF THE PECOS RIVER.

BY C. C. PARRY.

Having completed our general sketch of the external features of the country, as represented on the line of route in nearest connexion with the United States and Mexican Boundary Survey, we now retrace our steps, to detail more particularly the course of the Rio Grande, especially in its connexion with the extensive cañons by which its course is marked, above and below Presidio del Norte. In these we gain insight into the geological structure of a large and interesting scope of country, also connected with scenery unsurpassed for singularity and grandeur.

About 70 miles below El Paso the mountains on either side of the valley converge, and present a lofty barrier in the direct course of the Rio Grande.

Through these the river makes its way by deeply-cut chasms, exposing the geological formation and structure in the sectional faces presented by its precipitous walls.

We also see in this connexion the lower limits of that extensive aqueous deposit, forming what may be termed the *Great El Paso Basin*, which, by subsequent drainage in the progressive deepening of the bed of the Rio Grande, has brought to view the various terraced elevations marked along the course of the present valley in table-land bluffs and extensive gravelly plateaus.

In fact, in our progress down the river we shall have constant occasion to notice the connexion between these cañons, as marking the limits of upper basins of deposit. Thus the general course of the river represents a continuous series, in descending steps, of basins, more or less extensive, then a cañon, forming, as we may say, the *spout* of the basin, which again opens on a basin of lower level.

This simple statement embodies the great principle of formation that characterizes all this district, and gives to its topography a significance at once clear and instructive.

It is in these *barriers*, then, these *mountain dams*, that the character of the valley, as a whole, can be best studied, and the chasms by which the river pierces them furnish the true key to their geological development.

That portion of the Rio Grande thus marked by cañons and basins, extending from the first obstruction 70 miles below El Paso to Presidio del Norte, did not come under my own personal examination.

The river here follows a general *southeast* course, making its way through strata of disturbed carboniferous limestone, having usually a dip to the *southwest*. The river course thus cutting the strata unequally, we should naturally expect not so much of a continuous cañon as an unequal development of rock on either side, presenting, it may be, bold and abrupt faces on the one side, and comparatively low on its opposite, thus affording the means of following near the river banks, by crossing from one side of the stream to the other. This, indeed, seems to have been the course pursued by the surveying party, with their pack-trains, who were thus enabled to keep up a connexion with the line of survey.

We should also expect, as another consequence of this irregularity of feature in the rock exposure, not such a marked contraction of the river bend and channel as we should be more apt to find in the case of horizontal strata of equal development; rapids would be less apt to form, and lines of beach would be more frequent. Further on, in encountering the exposures of igneous rocks, these features would vary, and here would be the points characterized by greater obstruction to the regular course of the river, and also rendering a passage along its banks more impracticable.

Such are the general features, as well as they can be gathered from the maps of the survey and the geological features of the country through which the river here passes.

Approaching Presidio del Norte, the valley of the Rio Grande again opens upon a wide basin, closely resembling in all its external features that seen above, near El Paso. The table-land, however, attains a greater height above the river bottom, presenting steep bluffs, often 200 feet high. The river bottom is also more contracted, rarely attaining a mile in width, and frequently reduced by the adjoining table-land to a mere strip. The river spreads out, embracing in its course numerous islands of deposit, and forming frequent sloughs along its main banks, subject to regular overflows. It is to these several tracts, islands, and sloughs that cultivation is chiefly confined.

On the Mexican side the Rio Grande receives the waters of the Rio Concho, flowing from the southwest, and draining a large extent of country in the State of Chihuahua. This is the only constant tributary to the Rio Grande yet met with in our course downward; its waters at the usual height are clear, flowing generally over a bed of limestone pebbles.

The delta formed at the junction of this stream with the Rio Grande affords a patch of soil suitable for agricultural purposes, and is occupied by the Mexican settlement of Presidio del Norte. The town itself occupies a conspicuous site, on high gravelly table-land, overlooking both valleys.

On the American side, about three miles below the junction of the river, the greatest amount of bottom-land suitable for cultivation is met with; it is connected with the site known as Fort Leaton.

The bottom-lands in this vicinity are variously occupied by scattering growths of cotton-wood, willow, &c. The highest alluvial tracts are covered with a dense growth of mezquite; the table-land presents its usual desert vegetation.

The natural boundaries of this basin consist of irregular mountain ranges, composed principally of carboniferous limestone, similar to that seen above. As a general thing, the strata here appear less disturbed, but show not unfrequently a strong westerly dip.

In an east and southeast direction lies the range of igneous mountains called the "*Sierra*

Rica," forming the topographical limits of the basin in that direction. Through this range the river passes, and forms here the first of a series of gigantic cañons below.

There is no occasion to dwell longer on the general features of scenery connected with this Presidio del Norte basin. To apply the term *Rio Grandeish* would convey at once a clear idea to any one at all acquainted with the general aspect of scenery invariably connected with this desert stream.

This first cañon commences about twenty-five miles below the town of Presidio del Norte.

The general course of the river for this distance bears south 70° west, (*mag.*,) passing at several points rocky knolls of igneous character which abut on the river. On approaching the mountain range directly in front, it will be seen that the river, winding through the lower line of adjoining hills, suddenly contracts its channel, and thence tumbling over a series of foaming rapids, enters the mountain range.

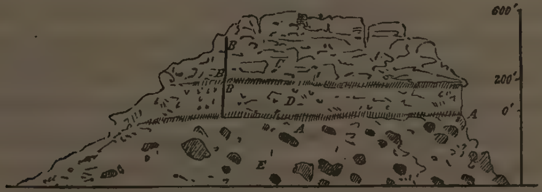
The rock exposure here is of a most remarkable character, and different from any heretofore met with. When the adjoining mountains, reaching a height of 1,000 to 1,500 feet, present a clear sectional face, we see a somewhat regular series, composed of lavas, vesicular or compact in texture, alternating with thick deposits, of an earthy form, of volcanic breccia.—(Specimen Rocks, No. 59 to 62 inclusive.)

The general arrangement of these formations shows them to be variable in thickness, and disposed in regular strata one above the other.

The dark-colored lavas form usually the upper capping, together with one or more intermediate seams. The intervening lighter colored breccias are often of considerable thickness, showing in some places a development of 300 feet or more, while at other points it is reduced to a thin seam. The usual appearance of these breccias is that of an earthy-stratified deposit, varying in color from a whitish brown to a dull green; its texture is more or less crumbling, being composed of a whitish paste, which contains, occasionally, minute pebbles of quartz rock.

In entering into the composition of mountain masses, these several formations assume very distinct and peculiar characters. Thus, where the earthy breccias are considerably developed, we see them exposed, along the sides of mountains, in perpendicular walls, capped by the darker colored lava rocks, which are frequently seen overhanging and forming a regular line of terraced platforms, thence rising upward in broken ledges to form a flattened summit. This

SECTIONAL VIEW OF BUFASILLA MOUNTAIN, NEAR THE COMMENCEMENT OF THE CAÑON OF THE RIO BRAVO, THIRTY MILES BELOW PRESIDIO DEL NORTE.



A. Lower exposure of trap-rock of closer texture than the upper stratum.

B. Vein of trap, six feet in thickness, traversing the intervening breccia formation, and connecting the upper and lower strata of igneous rock.

C. Vesicular trap-rock, dark colored, 400 feet ? thick.

D. Volcanic breccia in horizontal strata of light brownish color, 200 feet thick

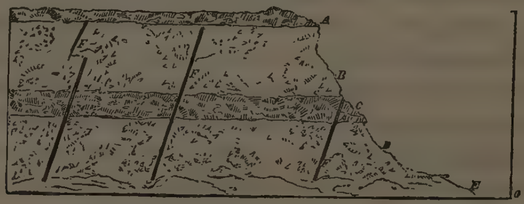
E. Talus strewn with blocks derived from the upper igneous stratum.

singular character of formation has given the name of "Bofecillos" to some of the more striking mountain ledges.

Owing to the crumbling nature of this underlying stratum, we find it variously washed and often fantastically shaped by the peculiarities connected with its various exposures; it thus frequently forms burrowing caverns and dark grottos, set off with misshapen pillars. Quite invariably we find its base occupied by a talus, derived from the overhanging rock, forming a rough slope strewn with irregular blocks; thus its connexion with the underlying rock stratum. This connexion is, however, occasionally brought to light, and shows a lower development of lava rock, differing but little from that above, except in a greater closeness of texture, the upper capping being generally vesicular, while that below is compact.

Frequently, however, a direct connexion between the separate lava strata is made by narrow dykes, identical in character with the rock above and below, passing through the intervening breccia. At other places, veins are seen shooting from above and below, and terminating in the intervening series.

SECTIONAL VIEW, SHOWING A SERIES OF VOLCANIC PRODUCTS, TRAVERSED BY INJECTED IGNEOUS VEINS; CAÑON OF RIO BRAVO, THIRTY-FIVE MILES BELOW PRESIDIO DEL NORTE.



A. Dark-colored vesicular trap.
B. Volcanic breccia of a lightish brown color in horizontal strata.
C. Lava or trap-rock of close texture, dark-colored.
D. Breccia as above, having a light greenish color.
E. Igneous veins.

We are now sufficiently prepared to appreciate the external features of the region thus characterized. We can understand how the unequal development of these several layers may give shape and character to the mountain ranges, and what diversified features they will necessarily assume, under the influence of denuding causes, acting so unequally on their separate members. The geological formation seems to conspire with the atmospheric influences to give a ruggedness and character of desolation to this region, of which description can give but a most meagre idea.

It is, however, in the line of the river-course that these rugged features present their grandest developments. We see the turbid waters of the Rio Bravo here contracted to a narrow channel, barely a stone's throw across, sweeping on a resistless current beneath bristling crags; now tumbling over foaming rapids, connected with some abrupt turn in the course of the stream, and then gliding smooth and unbroken through mountain clefts with perpendicular walls on either hand, rising to the dizzy height of 1,200 to 1,500 feet perpendicular.

In our progress through the range, the breccia deposit becomes less developed, and finally disappears altogether, or is seen only in narrow seams along the sides of the mountains.

The course of the river at first is not entirely hemmed in by abrupt rocky walls, a rough talus at the base affording a rude pathway, occasionally lined by narrow strips of sand beach.

At other places, however, all approach to the river, except by the route of its dangerous channel, is out of the question.

Along the course of the river, the mountain barriers are occasionally pierced by side chasms for the drainage of tributary mountain valleys. One of these is so remarkable as to deserve some separate notice.

At a point about seven miles from the entrance of the cañon, where the river is completely hemmed in on each side by the largest development of the mountain range, being unapproachable except in boats from above, there is a cut-off on the American side, leading by an open country over a gentle swell of ground, reaching the river about five miles below. This cut-off passes directly at the base of the high mountains intervening between this route and the river, having an average breadth of half a mile. At the summit of this swell is a depressed valley, the drainage of which leads directly toward this mountain barrier in its course to the river.

In following the dry-stream bed thus marked out, we find it entering by a narrow portal, about 15 feet in width below, thence cutting its way by a uniform cleft through the entire breadth of the mountains to reach the Rio Grande.

It thus presents a miniature picture of the larger cañon made by the Rio Grande. Its floor shows a smoothly-washed rock surface, in which basins frequently occur, bedded by washed sand and pebbles, and receiving the limpid issue of a small trickling stream. In its general course toward the river, it makes frequent zigzag angles, thus giving a new feature of scenery at every turn, and presenting altogether a most varied combination of the grand, grotesque, and beautiful. Along its sides is plainly observed a high-water mark, with an average height of 15 feet above the rocky bed, indicative of the sudden floods, derived from copious rains, to which this chasm is subject. This fact serves to give a somewhat nervous interest to its exploration. The height of the perpendicular walls on each side, corresponding to the thickness of the mountain range, is from 300 to 800 feet. The chasm thus formed opens up gradually towards the summit, forming a broken yawning abyss, untouched by sunlight, and having its depth exaggerated by the comparative dimness that shrouds it below.

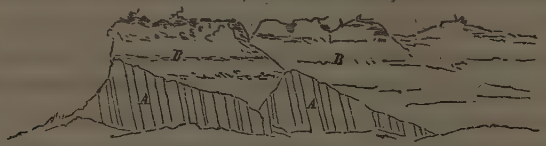
Thus sheltered from the sun's scorching rays, and cooled by evaporation from its brimming basins of clear water, with its entrance fanned by a constant stream of cool air, this cañon forms a grateful retreat. Further toward the river the descent is made by several abrupt falls, forming extensive basins below. These are filled with clear water, and offer natural bathing places of a most attractive character. Its exit on the river presents the same general features of chasm, the final *debouchment* being marked by a *débris* of rocks and pebbles, which project into the main stream and form a difficult and dangerous rapid.

About three miles from this latter point, and twelve from the head of the cañon, the main development of the mountain range forming the Sierra Rica is passed; the final exit is through a narrow rocky portal, and presents the appearance of an immense gateway. The width of the river at this point is barely 80 feet; the adjoining mountain ridge on either side is so broken and rugged as to be impassable for animals.

On passing this narrow outlet we come upon a more open but still broken country, consisting of basins of limited extent, set off with the usual form of gravelly table-land. The course of the river is frequently obstructed by low rocky ranges, forming cañons; again pouring out of these cañons into the more open basins, it becomes expanded, and forms limited sand beaches, patches

of bottom-land, and occasionally small islands. This character continues for ten or twelve miles, when we enter on a more extended basin, through which passes the Comanche trail, leading from Upper Texas into Mexico, by the adjoining Mexican settlement of San Carlos.

SECTIONAL SKETCH AT COMANCHE CROSSING, ON THE RIO BRAVO, BELOW PRESIDIO DEL NORTE.

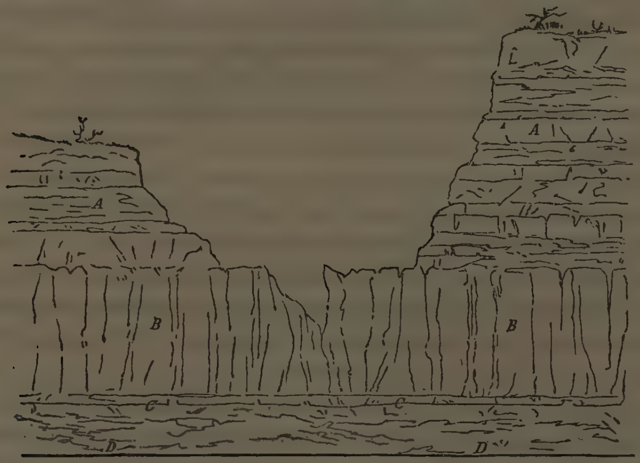


A. Cretaceaus limestone marked with large ossils of Inoceramus, inclining N. N E., at an angle of 80°.
B. Mesa, or gravelly table-land formation, resting unconformably upon A.

At this point the rock exposure exhibits outcrops of limestone belonging to the cretaceous period, being quite abundantly marked by fossil impressions of *Inoceramus*, often of large size. The rock exposure exhibits a very variable dip, mostly inclined towards the west, occasionally at a very sharp angle. It rises at various points in the adjoining table-land, forming ochreous colored rocky bluffs, where at several points the gravelly table-land is seen to rest unconformably on the sharply-tilted strata.

Further down the river, in an eastern direction, this cretaceous formation assumes a nearly horizontal position and a closer texture. It is here seen overlaid by a variable sheet of dark colored lava rock, corresponding in character to that noticed above in connexion with the Bofecilla mountains. This sheet of igneous rock is seen to conform closely to all the inequalities

SECTIONAL VIEW ON A RAVINE LEADING TOWARD THE RIO BRAVO DEL NORTE, NEAR SAN CARLOS, SHOWING IGNEOUS ROCK DIRECTLY ASSOCIATED WITH CRETACEOUS LIMESTONE.



A. Cretaceous limestone, having an earthy texture, containing fossils of Inoceramus, 150 feet.
B. Dark-colored igneous rock, 80 feet in thickness.
C. Cretaceous limestone of closer texture than that above, 15 feet thick.
D. Dĕbris.

of the underlying limestone, exhibiting in the walls of the cañon below a distinct line of separation, traceable for a long distance. The westerly dip of the cretaceous formation underneath gradually thins out this upper igneous capping, which finally disappears, and solid limestone walls continue along the line of the river.

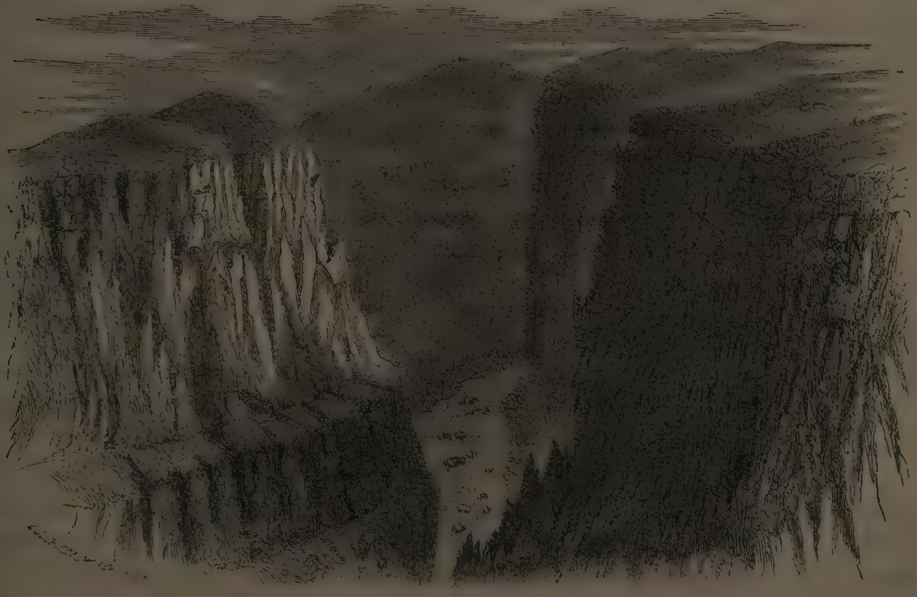
At one point on the line of the trail leading round the broken ranges of the mountain ledges, directly bordering the river, to reach its bed some eight miles below the Comanche Ford, the sides of a deep washed ravine bring to view the successive and relative thickness of the various exposures alluded to above.

We here see the upper members of the cretaceous rocks forming the tabled summits of the adjoining mountains, and marked by frequent cretaceous fossils, resting on a bed of igneous trap-form rock 50 to 80 feet thick, this again overlaying the closer layers of the limestone strata below.

Our further route, adjoining the river on the Mexican side, passes over high ground, based on limestone rock, and attaining a height of 800 feet or more above the river, the strata here dipping slightly to the west. We again reach the river-bed at the mouth of San Carlos creek, which, draining a considerable valley extending to the south some fifteen miles, affords a constant stream of clear water.

Just below this point commences the gigantic cañon of San Carlos, through which for ten miles the Rio Grande, pursuing a nearly due east course, makes its way. This cañon presents unbroken walls of cretaceous limestone.

The course of the river here cutting the strata in a line directly opposed to the dip, there is a



FALLS OF RIO BRAVO, NEAR SAN CARLOS.

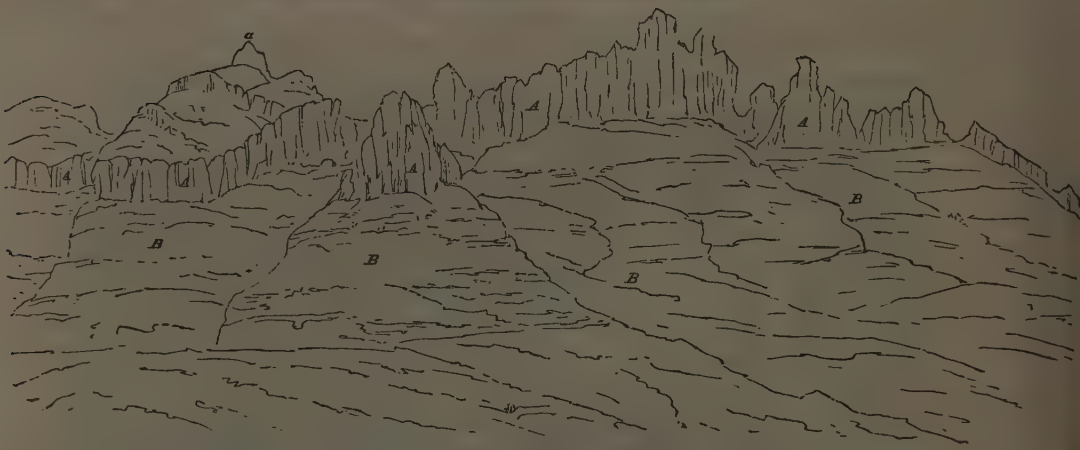
constantly increasing elevation of the cañon walls. These walls commence with a height of between 200 and 300 feet; but the fall of the water combined with the rise of the strata, develops, in the course of ten miles, a clear perpendicular height of at least 1,500 feet above the river level.

A faint conception only can be formed from these facts of the truly awful character of this chasm. Its course can be marked along the mountain slope in a regular zigzag line, terminating by an opening cleft, which rises high and clear above the surrounding mountain ranges.

The surface of the ground adjoining the river bank is a slightly broken slope, extending to the east, and showing a continuous development of the range to the north and south. The general surface presents no indication of a river course, and you are not aware of its presence till you stand suddenly on its abrupt brink; even here the running water is not always visible, unless advantage be taken of the projecting points, forming angles, along the general course of the river. From this dizzy height the stream below looks like a mere thread, passing in whirling eddies, or foaming over broken rapids; a stone hurled from above into this chasm passes completely out of sight behind the over-hanging ledges, and one can often count thirty before the last deadened splash announces that it has reached the river bed. From the point formed by its last projecting ledges the view is grand beyond all conception. You can here trace backward the line of the immense chasm, which marks the course of the river, till it emerges from its stupendous outlet.

Below this the country presents from a bird's eye view an extended basin, set off by the rugged volcanic mountains of the Chisos, we trace the winding of the stream in the basin below, to which distance gives a softening character of fertility not by any means borne out on a nearer inspection.

OUTLINE VIEW OF THE CHISOS MOUNTAINS, LOOKING TO THE NORTH.



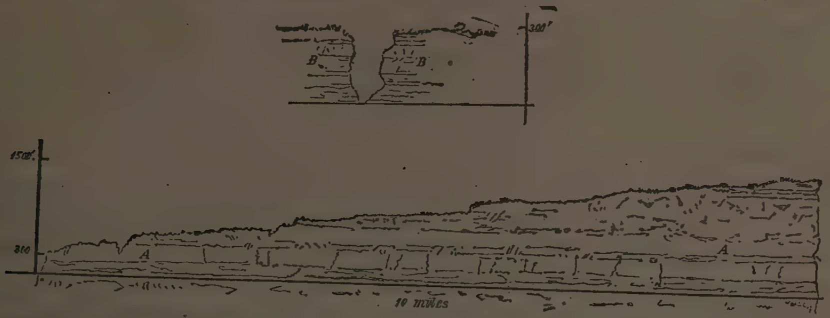
A. Dark-colored igneous rock of vesicular or close texture, disposed in vertical columns or horizontal masses.
B. Volcanic breccia in evenly horizontal strata, light-colored and of crumbling earthy texture.
a. Emory's Peak, 2,500' above the waters of the river, having the appearance of a crater.

Rumor had led us to expect, in connexion with this chasm, an extensive river fall, but such did not prove to be the case. Rapids, indeed, do occur sufficiently severe to render a safe passage by boats a virtual impossibility, but no distinct fall from an upper to a lower ledge of rocks was encountered by the surveying party. Indeed, from *a priori* reasoning, we should hardly expect to find such a feature in this location, where the strata are of such uniform texture, and where the evident marks of such long continued abrading forces tend to level the river bed.

All the rapids seen along the course of the river are connected either with a talus, thrown down from the projecting cliffs, or with the irregular deposit brought down from the beds of tributary streams.

Within this cañon there is rarely a foothold visible along the line of the ordinary water level, and at no place for the whole distance of ten miles would it be practicable to make a safe descent to the water's edge, still less to ascend. The "*facile descensus*" would here be truly "*Averni.*"

SECTIONAL VIEW OF THE GREAT CAÑON OF THE RIO BRAVO DEL NORTE, NEAR SAN CARLOS.



A. Perpendicular walls of limestone rock, having a gentle dip to the west, giving increased height to the walls of the cañon, along the eastern course of the river.

B. Cross section of the cañon, showing the general shape of the chasm. (Same scale, horizontal and perpendicular.)

Note.—For 300 read 800.

It would be barely possible, in a time of high water, to conduct a boat safely through this stupendous chasm. A strong wooden boat, which accomplished the entire distance from El Paso to this place in the service of the survey, being here cast adrift, was found in broken fragments along the river course below. There are rumors among the Mexicans living near here of the attempted passage of this cañon by some daring individuals, but no authentic record of a successful result.

A perpendicular cross section of this cañon exhibits a rather peculiar feature, at least such as is not noticed elsewhere: thus, instead of a regular slope or perpendicular descent of the cañon walls on either side, we have an expansion of the breadth of the cañon at two distinct points, above and below. The vertical cross section would thus correspond to that of a pitcher, showing first a flaring top, then a contraction, and again bulging out below; the peculiarity consists in this lower expansion, but is evidently susceptible of a ready explanation. Thus, it may be regarded as due to the irregular action of river flood and recession, acting along its pent-up course in such a way as to exert a greater denuding effect on the sides of the chasm than on its lower bed.

Professor Hall has suggested that such a shape would be apt to result, in such situations, from the gradual diminution of the body of running water, naturally connected with increasing land elevations.

The average width of the stream within this cañon is probably about 100 feet; and when we come to include herein the immense floods that in other places spread out the river overflows for miles, we can appreciate its terrible energy when pent up within such narrow limits.

Sufficient has, doubtlessly, been said on this most remarkable feature in the course of the Rio Bravo; its details, however, will have a general application to what is to succeed, and render a more elaborate notice of the successive cañons unnecessary, all of which resemble the above in general aspect, but none equal it in extent and grandeur.

In order to reach the lower basin in the course of the Rio Grande, beyond the San Carlos cañon, you have to make an extensive detour, and pass again up the San Carlos creek about ten miles to the "Old Presidio of San Carlos." This now deserted adobe structure is situated on the eastern side of the valley, occupying gravelly table-land, and overlooking the alluvial bottom, which shows the remains of former cultivation in extensive lines of irrigating ditches. The cultivation carried on by the present inhabitants of San Carlos is confined to the upper part of the valley. These cultivated fields extend some five miles, and present a rich belt of alluvial soil, abundantly watered and consequently fertile.

On leaving the San Carlos valley, we pass by a southeast course over an upland, gently undulating plain, set off by occasional rocky knolls, and encircled by mountains mostly of volcanic formation. Our course thence, inclining more to the northeast, leads over broken swells of the limestone range pertaining to the cañon above described. Thus, by a series of steep descents, the lower basin of the Rio Grande is gained at a point some distance below the mouth of the San Carlos cañon, and nearly opposite the range of the Chisos mountains.

The general character of the valley here presents the usual features of gravelly table-land, flanking a narrow alluvial belt along the winding course of the river. The bottom-land here is again bordered by cotton-wood and willow growth.

Towards the exit of the river, from the San Carlos cañon above, the general aspect of the valley is modified by irregular outbursts of eruptive trap rocks, confusedly alternating with volcanic breccias.

The general course of the river through this basin is easterly; the bottom-land is of limited extent, and generally barren. At several points here are seen Indian fords and broad trails leading from upper Texas into Mexico. These beaten paths are unmistakable indications of the route pursued by the Camanches on their extensive foraging expeditions.

These routes, both to the north and south, are comparatively open, and are apparently determined by the depressions that occur in the elsewhere uninterrupted line of mountains.

The continuation of our land route down the river compelled us to cross, with our pack train, at one of the Indian fords called "*Vado Fleche*," thence taking along the Texan side to turn the spur of the mountain range forming the San Vincente cañon.

This range is exclusively composed of cretaceous limestone, similar in texture to that in the San Carlos cañon above. It differs from that, however, in being of less height and extent, and in showing, in place of a regular western dip, a distinct anticlinal axis, the dip being quite abrupt on either side. Cretaceous fossils, identical with those found at San Carlos, serve plainly to characterize this formation.

The cañon of San Vincente is very abrupt and of considerable height; the ridge adjoining is also very broken, exhibiting steep descents and branch chasms, which rendered the survey extremely arduous. The passage through this cañnon was accomplished by our India-rubber boats, one of which was, however, capsized in shooting a sharp rapid. On emerging from this range, the Rio Grande opens on the San Vincente basin, in which, on the Mexican, side is situated the now deserted Fort San Vincente.

This basin differs from all others yet seen in being exclusively formed of low ledges of a dark-colored stratified rock, showing low bluff ranges 30 to 50 feet high. These ridges have a very uniform dip of 15° to the northeast; they occupy in great measure the place of the usual

gravelly table-land, forming along the *line of strike* open valleys. Arid and bleak sterility characterizes this formation, to which the scant and sandy bottom-land is hardly an exception.

Fossils are occasionally copiously imbedded in these ledges; among which principally *Ostrea*, *Ammonites*, and *Turritella* occur, and show that the formation belongs to the upper cretaceous series. At some points there is an evident approach to the lower Tertiary formation.

VIEW OF PRESIDIO DE SAN VINCENTE AND SIERRA CARMEL.

The eastern limits of this basin are marked by the extensive and elevated range of the Sierra Carmel, presenting directly in front an unbroken wall composed of a light-colored limestone. This shows a dip to the east. Its western aspect exhibits a line of perpendicular escarpment rising in several peaked knobs to a great height. The line of mountain wall thus exposed presents a series of terraced elevations, dividing horizontally the abrupt face of rock exposure.

Along these terraced lines, and associated with the talus there accumulated, is a growth of dark-green shrubbery, strongly contrasting with the ochreous-colored wall, which forms the background.

This mountain range further to the southeast exhibits an extensive development of igneous rock, showing in the distance a very rugged outline.

The occurrence of these several ranges forces the river from its east and southeast course, and gives it an abrupt turn to the north. The mountain barrier is thence passed at a lower elevation of the main range forming the *Carmel cañon*. The river here cuts through the limestone strata, showing a distinct dip to the northeast; after a course of 8 miles, the river emerges on the eastern slope of the Carmel range. To accomplish the same distance with our mule train a detour of 40 miles was necessary, leading again to the river at the point where it emerges from the mountains. The operations of the surveying party being here suspended, our route hence led southward to the Mexican settlement of Santa Rosa, thence to Eagle Pass.

The eastern slope of the Sierra Carmel shows the strata of cretaceous limestone inclining eastward at an angle of about 20°; its exposed face is variously marked up by irregular trenched valleys and abrupt points and ledges, due to the natural denuding forces of water drainage and atmospheric action. This slope terminates in an irregular valley below, having its drainage to the north, and leading direct to the Rio Grande. Further south is conspicuous the extensive igneous development of the mountain range, rising in jagged peaks to an Alpine height, and presenting in the forest growth, which clothes its sides, agreeable features of verdure, contrasting strangely with the river valley and its bare outline of desert hills.

The most northern outlier of this igneous formation is the singular peak known as the "*Picotena.*" Lying at a distance of about 5 miles from the river, it rises abruptly from amid the surrounding limestone ranges, shooting up a sharp conical peak of basaltic structure. This peak, by its height and external features, presents a most striking landmark.

The country stretching to the north and east in the course of the river is less interrupted by high mountain ranges than has yet appeared on the line of our route, and presents features precisely similar to those before noticed in connexion with the lower valley of the Pecos. Igneous exposures disappear altogether, or are of very limited extent, and the limestone strata are but little disturbed. The numerous deeply cut valleys leading to the river are bounded by abrupt walls, rendering travelling, except in the direct line of their drainage, next to impossible. In attempting to follow down the river with pack animals, the only practicable course was to follow up to near its head one of these tributary ravines, thus reaching the general table summit, and then to pass over to and down another ravine leading to some uncertain point of the river below. By this plan it not unfrequently happened that, in order to make a distance of 5 or 6 miles by the line of the river, a detour of 30 miles or more was necessary. Each of these detours, moreover, leads over a country destitute of water, except the uncertain rain water retained in rocky wells, which generally occupy positions inaccessible to animals.

This character of country continues hence uninterruptedly to the mouth of the Pecos river, about 80 miles distant, presenting great uniformity in the general external and geological features of country.

Our course led along the eastern base of the Sierra Carmel, bringing to view, in connexion with its larger development of igneous formation, a section of country extremely picturesque, including well watered valleys, timbered mountains, and upland plains covered with a luxuriant growth of nutricious grass.

Indian traces abound in these vicinities, and the deep recesses of the adjoining mountains afford secure retreats, where the animals plundered from the Mexican settlements are driven to recruit, in preparation for their passage across the Rio Grande into Texas.

To this character of country again succeed ranges of cretaceous mountains, showing a general easterly dip of strata, and connected with upland basin plains mostly waterless.

At a distance of about a hundred and fifty miles south from the Rio Grande we reach a system of elevated basins, having frequently a drainage distinct from the valley of the Rio Grande, forming extensive inland lakes fed by numerous rivers. The noted *Bolson Mapimi* is the largest example of this lagoon formation.

Several, however, of these lagoons on the northern edge of this elevated area give rise to tributaries which empty into the Rio Grande. Of this latter class, the "*Laguna Agua Verde*"

is an example. Along the line of one of these valleys last mentioned our route led, thus threading our way through the mountain barriers, forming the northern line of the Santa Rosa range, thence emerging on this charming valley a short distance above the town of Santa Rosa.

The route thence to the Rio Grande at Eagle Pass is over an open country, occupied by low swells of cretaceous limestone, thus merging into that character of country pertaining to the region of central Texas.

For further details of the lithological character and fossil contents of the various rock exposures above alluded to, reference may be had to the lists of Mr. Conrad and Professor Hall. A very interesting paper from the latter gentleman also contains important generalizations, derived from examination of the various geological specimens collected in this and other expeditions.

The numerous illustrations of scenery from various sources will supply all that can be desired in regard to the general aspect of the region under consideration.

CHAPTER IV.

GEOLOGICAL OBSERVATIONS ON THE COUNTRY ALONG THE BOUNDARY LINE LYING BETWEEN THE 111TH DEGREE OF LONGITUDE AND THE INITIAL POINT ON THE RIO COLORADO.

[By Arthur Schott, Assistant U. S. B. C.]

Geographical terms for this section of the boundary line would be Sonorian or Pimerian, as it runs through the northwestern part of Sonora, which also bears the old Spanish name of Pimeria Alta (High Pimeria ;) and since it intersects both meridians and parallels in an oblique direction, it is called, in geodetic language, "azimuth line." This line lies entirely on the eastern slope of the basin of the Gulf of California, and falls on *the divide* separating the waters of the Gila from the streams of Northern Sonora, which, after flowing in a southwesterly course, empty into the Gulf of California.

The hypsometrical and general geological features can only be expressed approximately, for circumstances prevented actual measurements.

At the eastern end of the azimuth line is the Sierra del Pajarito, from the highest point of which an imaginary line drawn to the Rio Colorado would give a grade of about 22 feet to one mile, or its equivalent, 0.41 to 100. The highest point may be set down at about 5,200 feet above the level of the sea. This point does not, however, reach the pine region, which in this latitude may be considered as occurring at an elevation of not less than 6,000 feet. A monotonous simplicity is a characteristic of the topographical features of Northwestern Sonora ; and but for a close examination, there would only be disclosed a mere dualism of diluvial drift and pluto-volcanic mountains. The drift covers many of the mountain ranges almost to the tops, particularly those which approach the bottom-lands of the Colorado.

The northwestern part of the line runs over what may be called a veiled country ; for of the mountains, only their crests are to be seen above the desolate sand-flats of the general level of the surface. It is through these forsaken barrens that the Rio Colorado, with its timbered bottom, winds its course towards the waters of the Gulf.

Comparing the geological edifice with the structure of animal organism, the mountain ranges jutting up through this vast level of drift represent the skeleton ; the diluvial main the sinew and muscle ; and the alluvial deposits the tegument or epidermis. The last mentioned is poorly represented. The scant vegetable cover facilitates, however, the observations of the geologist.

Alluvium is seen first and as the uppermost stratum ; except at the extremities of the line, there is, however, but very little to be met with. As might be expected, it abounds most in the bottom-lands of the Colorado ; but, strange to say, it is even in greater abundance on the highest mountains than on the plains. It frequently collects in such quantity in the little valleys and in the cavities of the broken sides of the mountains as to give rise to a more complete develop-

ment of vegetable life. The plains exposed to the drifting sand as well as to climatic severities are almost wholly deprived of an alluvial coat. A few traces may be looked for at the so-called "Playas," (depressions in the plains.) What little rain may fall collects here, and bringing down with it the lighter particles of the surrounding soil, affords a foothold for vegetation, which presents, however, more a mass of equals than a diversity of species and genera. Often, apparently, this premature effort of nature to develop vegetation is sadly counterbalanced by the saline character of the soil, which causes the prevalence of corresponding forms, as obione, salicornia, salsola, chenopodium, and others, in the place of algarobia, prosopis, or even salix, the usual types in analogous localities.

The plains lying between the mountain ranges are formed of a more or less uniform deposit of loose diluvial sand, its composition not differing essentially from that of the adjoining mountains. This diluvial main may, therefore, be called the debris of the adjacent mountains and of the underlying mass.

As to the formation of this diluvial main, we incline to the opinion that it is the residue of a sea once a connecting link between the waters of the Atlantic and Pacific. Changes in the constituents of this deposit certainly occur; but they are of a local character, besides having a certain uniformity. Fragments of quartz, mica, feldspar, and other similar elements of crystalline and igneous rock, associated with calcareous particles, constitute the formation of that vast region of deserts stretching from the eastern foot of the California Cordilleras to the table-lands bordering even the Rio Bravo. This section of country may thus be viewed as the bed of an ocean variously intersected by numerous reef-like or dyke-shaped mountain ranges.

In the immediate vicinity of the mountains, isolated beds of pebbles are sometimes seen, the lithological character of which indicate their origin. These pebbly beds, however, must not be confounded with similar ones occurring occasionally about the centre of the desert basins and frequently along the dry water-courses. The former are the disintegration of the rocks, unmoved from their original locality, whilst the latter are gatherings of an immense area. The latter bear evidence of being brought from the most opposite and most remote geographical quarters; pieces of limestone representing both the carboniferous and cretaceous periods with tertiary and even traces of lime recently precipitated; these fragments are mingled with agate, chalcedony, semi-opal, opal, jasper, slates, silicia, breccias, and crystalline and amorphous conglomerates; here, also, are silicified, agathized, or opalized fragments of wood side by side with pieces merely incrusted—scarcely metamorphosed or entirely unchanged, and of quite a recent geological date; semi-opal, formed entirely of shell, whose age is readily recognized by the numerous nummulites associated with it; agate, with neat fragments of encrinitic or coraline forms; jasper or hornstone, which, under a common lens, discloses both the texture and grain of coniferous wood; opal, exhibiting traces of the structure of fossil-wood, with distinct annular concentric rings, but no marks of the grain could be detected; glass-opal, and hyalite, containing casts of some forms of the coral age pisolites, in appearance like a toadstone, which are either unchanged or metamorphic. The deserts of both sides of the Colorado and along the Gila abound with these pebbly beds, surrounded by and occasionally entirely buried in the sand. To the scientific observer they are pearls of this vast terrestrial ocean, which once formed the bottom of a sea, whose currents in all probability collected these pebbly deposits. Since the

water has receded, an ocean of a more subtile character sweeps over this area. Ærial currents are now driving the shifting sand from place to place as the waters of the sea once did.

Besides the general inclination of the western slope of the Sierra Madre towards the Gulf of California, an increased inclination of stratum is perceptible around the bases of the intersecting sierras. This does not, however, affect the mean ascent of the main land, and may be ascribed solely to the deposition of debris, as the angle formed by the inclination of the diluvial deposits was observed (particularly in the valley of the Santa Cruz river) to be $= 2.5°$.

The general ascent already referred to is conclusive proof of the action of upheaval forces since the deposition of the quaternary or diluvial drift. A straight line over its surface from the valley of the Colorado to the foot of the Sierra del Pajarito, where it ceases, gives a grade of 12.44 per mile, or 0.23 ft. in one hundred. In some valleys heading on the slopes of this sierra this deposit may be seen; but its occurrence in such localities being exceptionable, does not affect the mean angle of inclination of the stratum.

The height to which this diluvial main rises, in its approach to the Sierra Madre, gives a striking peculiarity to the features of the country. But for it the rugged crests of the sierras would be scarcely accessible.

If the climatic conditions were favorable, these now bleak and forbidding mountains would present a region teeming with vegetable and animal life. Instead of that, this country now lies an arid waste.

The few periodical streams descending from the mountain sides share a similar fate, for no sooner do they reach this drift than they disappear from the surface, sinking to unknown depths, and leaving only in the vicinity of the mountains slight marks of rudimentary drainage, clumps of shrubbery bordering dry water-courses.

The vegetation peculiar to the diluvial main is similar to that of the corresponding localities on the eastern side of the Sierra Madre and west of the Colorado. Besides smaller and more inconspicuous forms, are the Larrea, Fouquiera, Obione, and other chenopodiaceous shrubs; there are also a variety of leguminous plants, numerous members of the Cacti family, and some few bushes and trees, all well known to the traveller whose fortune has led him through these desert regions.

In passing to the consideration of the underlying strata—those upon which the diluvial deposits rest—a deep step is made at once; constituents of the secondary age seem to be wanting. Crystalline rocks of primary and transition age—more or less metamorphic—constitute the bed upon which the diluvial deposit lies. This bed does not occur as an even or slightly inclined plane, for its surface is variously broken by eruptive masses. These upheavals have not only disturbed and protruded through the primary and metamorphic strata, but carried with themselves masses of the latter above the level of the supercumbent deposits. Thus are formed the mighty sierras now representing the frame-work of our geological edifice, most of which may be distinguished as Pluto-volcanic.

With the hypsometrical features of these sierras, better called cordilleras, three important peculiarities are connected. These are, 1st. Parallelism among themselves, with the Gulf of California, and with the Pacific coast. 2d. Articulation. 3d. General petrographic relationship.

The parallelism is a fact now better understood than the natural laws which effected it. The linear extension of the axis may be supposed to be the result of electro-magnetic forces combined with the action of tidal currents, together with other causes, such as isothermal, isoclinic, and isodynamic currents. We offer the following explanation, founded on our own observations: After the first formation of the dykes and reefs composing the sierras, the result of volcanic forces, acted upon by electro-magnetism, sedimentary strata commenced to be formed. The igneous forces, however, at this time prevailed, and as a consequence, the strata of that era exhibit a crystalline character. By the increase of volcanic detritus and sedimentary material, the igneous ejections were confined to certain fissures only, whilst the action of aqueous forces became more general. The crust thereby becoming more and more firm and overlaid, the molten masses had to seek other outlets, determined, perhaps, by the character of the sedimentary rocks through which they led. To the stratification, lamination, and cleavage of the sedimentary rocks, as determining the subsequent direction of these volcanic forces, we may ascribe the formation of the catenary mountain ranges and dykes, and the cellular system of their intermediate bases.

The mountain ranges are mostly one-sided upheavals of metamorphic strata; the dykes, on the contrary, are essentially volcanic eruptions. The two classes of mountains are seen in a diversified combination of volcanic, plutonic, and aqueous or sedimentary rocks; syenitic and granitic lavas; trachyte and trap still exhibiting clear traces of lamination, cleavage, and stratification; granite, gneiss, syenitic, and various transition slates. How far this view may agree with the observed geognostical data, the special survey will show.

Before entering on this subject, we propose some remarks on a few Spanish terms which define their objects with a precision that could hardly be otherwise arrived at except by much circumlocution. These words are—

Cordillera, which means a long, continuous range of mountains, composed of several ridges, sometimes united by cross spurs, and intersected by passes or narrow valleys. The essential characteristic of this word is, that it means a mountain composed of two or more ranges forming one orographical body, just as several strings twisted together make a cord. The words cord and cordillera are formed from the same stem.

Sierra, a saw, indicates a mountain range with a serrated crest. A cross section of either sierra or cordillera is very small compared with its longitudinal axis.

Cuchilla.—This signifies a branch or outrunner of a sierra, which it usually resembles in its physiographical character. Its sharply edged crest, in all probability, suggests its name—cuchilla meaning knife.

Picacho means a sharp peak rising conspicuously above a surrounding mass of mountains; its height bears the same proportion to its width that the longitudinal axis of a sierra does to its cross section.

Puerto—a gate, or gap, and also a post. In its topographical application, a pass over or through a mountain range.

Cañon implies a defile or mountain pass without any outlets on either side.

Loma is a long mountain, or ridge of hills, with a somewhat smooth and flat surface. *Lomita* is the diminutive form of the same word.

Mesa is a table-land, table-mountain, or a flat-top ridge. *Mesilla* is the diminutive.

Malpais—literally, bad land; the "Mauvais terre" of the French. In Sonora it is exclusively applied to mesas, lomas, or any more or less elevated plateau formed of igneous rock, here mostly a compact or vesicular trap or basalt.

Ciénaga is a valley, or depression in a plain, where the water collects, and can only escape by an obstructed outlet. Such a place is usually miry and boggy.

Charco means a hole in clay, or stratum of rock, where water collects, and from which it cannot run.

Tinaja is a water-hole, found in the crevices of rocks and ravines, difficult of access. The primary meaning of this word is an unglazed earthen jar, burned so as to allow exudation. The water thus oozing through evaporates and keeps that remaining inside cool.

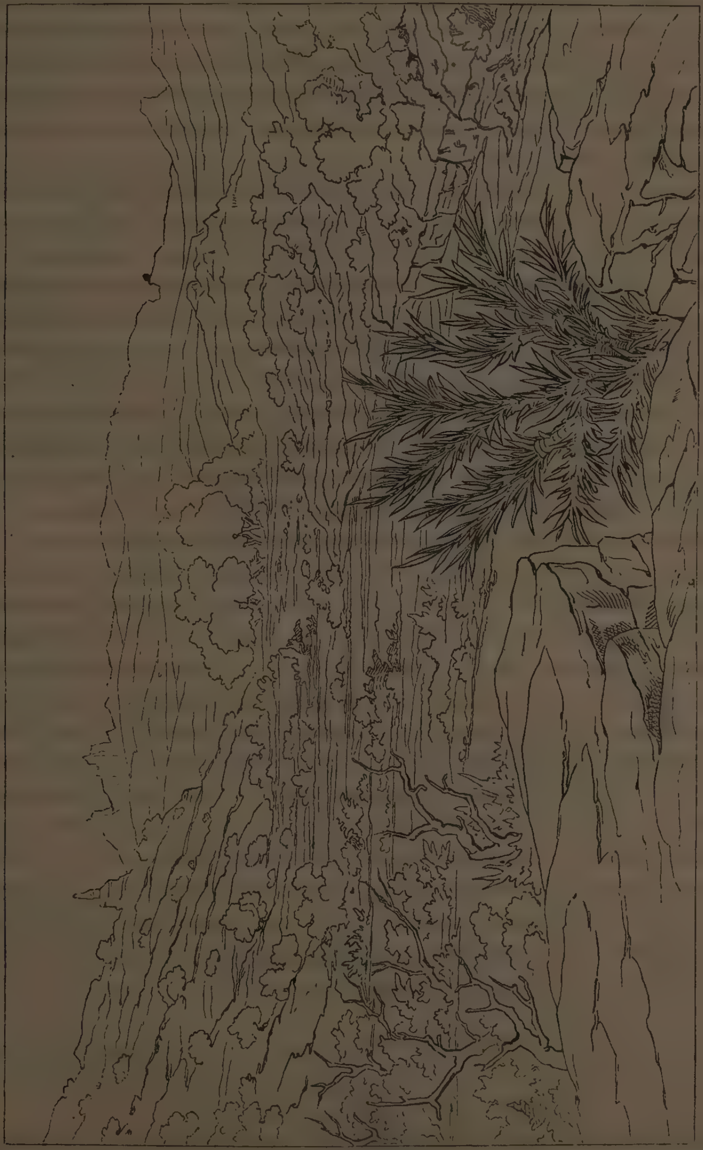
Beginning at the intersection of meridian 111° and parallel 31° 20′, we proceed to the consideration of the various sierras crossed by the line.

The Sierra del Pajarito (little bird) shows crystalline transition rocks, metamorphic and unchanged; also, trachytic strata, or metamorphic forms of granitic and syenitic rocks, (E.) Some of the more elevated portions exhibit a rough cellular surface, whilst the lower are smooth and more compact. The tint is light pink, or flesh color. This rock contains much glassy feldspar, and, occasionally, particles of augite, indicating the frequent occurrence of a syenitic granite. A fine-grained, white, metamorphic syenite, consisting of minute particles of hornblende and white feldspar, occur on some of the cuchillas on the north side. On the lower parts of the west slope talcose (argillaceous) and quartzose slates are met with, though trachyte dykes range through in every direction; in the bottom and slopes of the valleys the igneous rocks prevail. In one place a solid mass of trachyte is cut through by an arroyo, forming a puerto, flanked on both sides by vertical walls of eruptive (A and C) rocks fifty feet thick. The mountains on both sides slope towards this gap at an angle of 35 to 40 degrees. Here, and other localities along the foot of this sierra, pudding stone, volcanic breccia, feldspathic porphyry, and trapitic amygdaloid rocks abound. Some of the water-beds are lined with a singular formation, (B,) and apparently of a later age than those just mentioned. At first sight it may be considered a fresh-water deposit, overlying or placed alternately with volcanic breccia.

SECTIONAL VIEW OF THE VALLEY DE LOS JANOS.

Occasionally traces of stratification, and even cleavage, are visible, especially in its upper part; its lower portion is cemented into a solid mass. Its color is a light brown, or dark ash-gray. The outer crust looks as if it had been subjected to a process of calcination, for it readily crumbles or exposes a marl or chalk-like substance that could be easily scratched out with the finger. There were no means at hand to identify this as carbonate of lime; yet we were

inclined to the belief that the whole mass of apparent fresh-water deposit was cemented by this material, which also formed the matrix of the volcanic breccia. The trapitic and amygdaloid rocks (F) appeared everywhere, no matter how great the elevation, slightly blended with carbonate of lime, as if it had been precipitated there by water. This calcareous precipitation was espe-



VALLEY OF "LOS NOGALES."

cially perceptible in the vesicular cavities of every trachytic or basaltic boulder, and also in the fissures of the rocks and in the dells where these latter are imbedded.

On the east slope, in the valley of "Los Nogales,' (Walnuts,) similar strata line the various

water-courses, sometimes forming a continuously winding low bank, or terrace, on both sides, and sometimes covering the slopes of the adjoining mountains, composed of metamorphic rock.

On the hill-sides there are beds of this formation dipping towards the valley, and exhibiting, by decurrent, undulating lines, a shaly, laminated texture. On the easternmost limits of this valley the same formation is still more developed; and it can be seen in all the valleys to the south and southeast of the Sierra de Santa Barbara, which is a part of the cordillera embracing the Sierra del Pajarito. The volcanic breccia, in many of the ravines, form walls of from forty to fifty feet in height, varying from an angle of forty-five degrees to perpendicularity. Pieces of this breccia, heated in a log fire, and then thrown into cold water, showed much effervescence, without fracture.

North and northwest of this mountain range, bearing east and west, the Sierra Janos rises up in bold terraces of dark-brown amygdaloid trap and porphyry, the broader terraces being nearer the base. These gigantic shelves are bordered with rocks projecting out in the most fantastic shapes. They incline toward the main body of the sierra—deep and lateral valleys intervening. A huge block, exhibiting on its south and west side gigantic walls, with distinct stratification and cleavage intersecting at right angles, constitute at once the centre mass and the peak. The rectilinear fissures are visible at a distance of ten or fifteen miles, and giving the igneous walls more the appearance of mason-work than the result of volcanic action.

This sierra's vernacular name, "Janos," bears no reference to its petrographic character. The word signifies, in the language of the Papago Indians inhabiting this country, an arborescent shrub of the bignoniaceous order, belonging to the genus "Chilopsis." Its frequent occurrence here in the water-beds in this vicinity may have originated the name.

On the northern slope of the Sierra Janos another group of mountains occur, known as the Sierra Atascosa. Its bearing is the same as that of the Sierra Janos, and its longitudinal axis is common to this sierra and that of Sierra del Pajarito. All these three links of the cordillera have both dip and strike alike, the dip being to the east. Its petrographic character is similar to that of the Sierra Janos, and, being closely connected orographically, may be considered its twin. The cordillera formed by these three mountains terminates with the Sierra Atascosa, which is separated by a narrow and rugged valley from the Sierra del Babuquibari, lying to the northwest. This valley is of some importance, not only for its valuable fresh-water springs, but also as affording the only means of communication between the settlements of the Santa Cruz River valley and the coast regions along the Gulf of California. A rancho was once established at these springs, bearing the Papago name of Aribaca, or, more properly, Aribac. The settlement has, however, been abandoned long ago, in consequence of the repeated depredations of the Apaches. The northwestern part of the sierra is composed of igneous rocks, towering up into peaks of the most grotesque form, and bearing, not inappropriately, the name of "Malpais."

Atascosa means "miry," which probably has reference to a previous state; it now presents the appearance of being an upheaved, boiling, volcanic pool. This sierra and that of Janos have about the same elevation above the Santa Cruz valley.

Springs abound about the Sierra del Pajarito, but their drainage being, for the most part, below the surface, it requires a well-practised eye to detect their presence, particularly during the dry season, which occurs in April, May, June, and sometimes July. There is a considerable

development of vegetation on this sierra; the rough surface of its sides is covered with a dense growth of shrubbery, of which some are quite trees, and grass is luxuriant in all the valleys. There are several species of oak, and on the summit is found a cedar; though this ridge does not fully reach the pine region. This sierra partakes of all the physiographical features of the Santa Barbara, Santa Cruz, and other links of the Sierra Madre further east. The Sierra del Pajarito, with its dependencies already referred to, constitute one and the same mountain system, properly characterized by the word Cordillera, and, taken collectively, are known as the Arizona Mountains. This word probably belongs to the soft Papago language, but we could not learn its meaning. The Arizona Mountains are rich in silver, copper, and gold; evidences of numerous and well-worked mines are still to be met with. The eastern slope of the Sierra del Pajarito (Los Nogales) is especially worthy of exploration with reference to a development of its mineral production. Specimens of silver from this locality were analyzed, and the result will be found in its proper place.

The Sierra del Pajarito constitutes a part of the divide already referred to, and has been intentionally dwelt upon at length for the purpose of referring the other sierras to it as a standard of comparison in consequence of its typical character, both as to its hypsometrical and geological features.

Looking westward from the peak of the Sierra del Pajarito, a rugged net of mountain ranges is spread out, made up of metamorphic rocks; and though the single sierras do not rise very high, they form a very bold mountain relief by the close, uninterrupted texture of the inclined plane which constitutes them. (See outline sketches Nos. 34 and 35 of the azimuth line.)

At a distance of about sixteen miles another cordillera is visible, between which and the Sierra del Pajarito very little drift occurs; and this is confined only to the intervening valleys, where mesas and lomas, forty to fifty feet in height, are formed by the drainage from the surrounding mountains. Near where the drainage from the east slope of the Sierra de la Escondida joins that coming from the southwest side of the Sierra del Pajarito, a point just south of

SECTION ON THE NORTH SIDE OF THE CERRO DE SONORA.

the line, permanent water is to be found. It is under a cleft of igneous rocks, and does not properly deserve the name of a spring, but is rather a tinaja supplied by water trickling through the rocks from water-holes above. From the character of this place is taken the name Escondida, (agua escondida meaning hidden water,) a term which is generally applied to the whole sierra. In its orographical character, this sierra is but a volcanic dyke, (A) towering up into an isolated, rugged crest of igneous rocks, composed of amygdaloid, porphyritic, and trachytic compounds, intersected and overlaid by contorted and overthrown crystalline strata of a coarsely-grained and frequently disintegrating feldspathic syenite (B.) This syenite is sometimes meta-

morphic, at other times unchanged; sometimes it is quartzose, and imperfectly mixed with large scales of silvery mica, in other places feldspar prevails.

This sierra is scarcely more than one mile wide where the line crosses it; both sides are bordered by the upheaved and contorted crystalline beds just alluded to. We ascended to the top of this sierra, near where the singular-looking peak that marks the Escondida towers up, and found it to exceed in barrenness either of the sierras—Pajarito, Janos, or Atascosa. Portions of the terrace-like slopes, and also the plateau, are covered with patches of white or pearl-colored chalcedony, investing the rocks with a scoria-like crust of that silicious fossil. The southern part exhibits a more horizontal arrangement, leading to the supposition of having been formed under water; for here are extensive table-lands, ridges, lomas, and mesas, composed partly of black vesicular or compact trap, and partly of real quaternary banks. The topography of the country seems to indicate here the confluence of numerous mountain streams and torrents coming from every direction. (See sketch No. 40 of azimuth line.)

The line crosses a little to the north of a conspicuous peak(D)—the highest point of the whole range—and falling on the Mexican side, we gave it the name of "Cerro de Sonora."

Immediately west of the Sierra de la Escondido a low group of granite hills(C) occur, furnishing several temporary, as well as permanent, water places, apparently well known to the natives—Papagos and Apaches. Some are mere tinajas; others real springs, though liable to become dry before the setting in of the rainy season. While encamped here we experienced a heavy hail and thunder storm; in a few minutes water came rushing down the ravines in a torrent, five feet deep, carrying everything before it, and giving us unmistakable proof how little time it requires to submerge all the valleys around under a most terrible flood of rain-water. This mountain group was called "Granizo," (hail,) and is so designated in the maps from the circumstance of the surveying parties being overtaken here by one of those hurricanes peculiar to these regions.

A flat valley, nine miles wide, separates the Sierra de la Escondida and the adjoining Granizo group from the Sierra Verde, which is a southern spur or branch of the Sierra del Babuquibari, north of the line. The plateaus bordering the dry water-courses of this valley furnish fine grass, and are sparsely covered with well-developed hackberry and liveoak. The Sierra Verde, so called because of the verdure encountered in the shelter of its rocky valleys, seems to be formed exclusively of feldspathic granite, similar to that already mentioned as occurring on the east slope of the Sierra Escondida. The strike-side faces southwest, and with a width of scarcely more than a mile, this sierra does not present any petrographic novelties. Its longitudinal axis ranges southeast and northwest, and joins the bold walls of igneous rocks belonging to the Sierra Babuquibari. At its southern end mounds of dark, vesicular trap crop out of the diluvial main. Here water finds its way to the surface, forming a spring known as the "Pozo Verde," (Green Well;) the bunches of rush, which at once conceal and mark the water, in all probability gave rise to the name.

Almost due north of the Sierra Verde lies the picacho of the Sierra del Babuquibari, which is one of the orographical phenomena of the country, its peculiarity being such as to attract especially the attention of the red man. The Papagos consider this huge mountain obelisk their palladium; here they take refuge in times of famine, drought, or war. Babuquibari is said to signify "water on the mountain." The word is certainly formed from babu (water) and ari

(rock or mountain.) Its great height, added to its spire-like top, causes it to act as a conductor to the clouds, and thereby gather an unusual quantity of rain, which is retained for a long time in its numerous rugged and inaccessible recesses. (See outline sketch No. 39, azimuth line.) Viewing the country westward from the Sierra Verde, a wide plain is visible, bounded at a distance of fifteen miles by a mountain range traversing the country with the invariable bearing southeast and northwest.

The eastern half of this plain is favored with a more than usual cover of vegetable life—abounding in grass, a dense growth of brushwood, and mesquite; the western part, a low flat, was entirely destitute of vegetation, which seemed to have been destroyed by small trogloditic quadrupeds of the order *Rodentiæ*. Although this plain had received copious showers of rain a few days previous to our visit, singularly enough no life was given to the naked and barren flat. A change, and not to its advantage, is here perceptible in the physiographical features of the country, and becomes quite decided in the next mountain range, which is unlike all the sierras eastward, and which presents an isolated group rising out of the diluvial main.

Notwithstanding its lesser extension, the Sierra de la Union presents no peculiarity in its petrographic character—being a compound of igneous and metamorphic rocks. The latter constitutes the greater portion. On the east slope feldspathic granite in a disintegrating and somewhat metamorphic state occurs; on the west is a quaternary granite, similar to that mentioned as occurring on the Sierrita del Granizo. The backbone or central mass is formed of igneous amygdaloid and porphyritic rocks, here and there overlaid and concealed by crystalline strata.

Thus far there has been but little room for the diluvial deposits, so broken up is this region by the continuous succession of mountain ranges; but westward, great basins of quaternary and alluvial deposits form the main in which the sterile mountains lie imbedded and completely isolated by this vast sea of drift. Of the sierras ranging eastward, parts of them are so entirely submerged as to appear detached and isolated mountains, their connexion being traceable only by their general bearing. The country passed over may be viewed as a narrow strait, traversed by long mountain reefs, and that, in part, as a coast of shoal water dotted with rocky islands. The influence of the climate of the Gulf coast, as far as the Sierra de la Union, is quite apparent; on its west slope two leguminous trees, the Palo verde and Arbol de hierro of the Mexicans, Cercidium floridanum and Olneya Tezota, three large Cerei, two gigantic Echinocacti, and other desert forms, now appear in prevailing numbers.

The line, after crossing a desert of about seventeen miles, strikes a comparatively low and narrow sierra, composed chiefly of porphyry and amygdaloid rock. This sierra presents two vertical peaks, rising up like a pair of horns, which constitute natural monuments for the line as it falls between them. It is a northerly continuation of the Cordillera Cobota, so called by the Papago Indians, who have several fixed settlements here. There is a cañon in this sierra, near the line by which the west side is easily gained, and in which are seen masses of crystalline rock; igneous strata, however, prevail. The name "Lindero" (boundary or landmark) was given to this sierra, because of the line falling between the two conspicuous peaks before mentioned.

The sierras Arteza and Soñi lie, respectively, southeast and northwest; the former in the United States, the latter in Mexico, both well known and famous among the natives as being

remarkably auriferous; especially Soñi, once a mining settlement of the Mexicans. It was abandoned at the time of the California gold fever. The latter subsiding, the old settlers, disappointed on the Pacific coast, are now returning again. The Papagos claim this region, and, from the time they first learned to appreciate the value of gold to the present day, have continued to prospect successfully.

A desert of sixteen or eighteen miles in extent separates the Sierra de los Linderos from that of la Nariz. Though these sierras are nearly related in petrographic character, there exists one striking difference. The former is, at least where it was crossed, a true volcanic dyke, bordered in some places by upheavals of crystalline strata; its crest of eruptive rocks seems to have been forced through a mass similar to itself. The latter, though consisting also of trachyte and trapitic masses, appears only a simple upheaval; its crest, comparatively smooth, is the upturned edge of a bed of igneous masses, dipping northeast; its strike faces the west, at an angle of 60 to 70 degrees. The surface (B) of the east slope is covered with a thick layer of loose boulders, of a black or dark-brown vesicular trap. On the strike, stratification (A) is visible, even at a considerable distance, the layers varying in thickness from five to twenty-five feet.

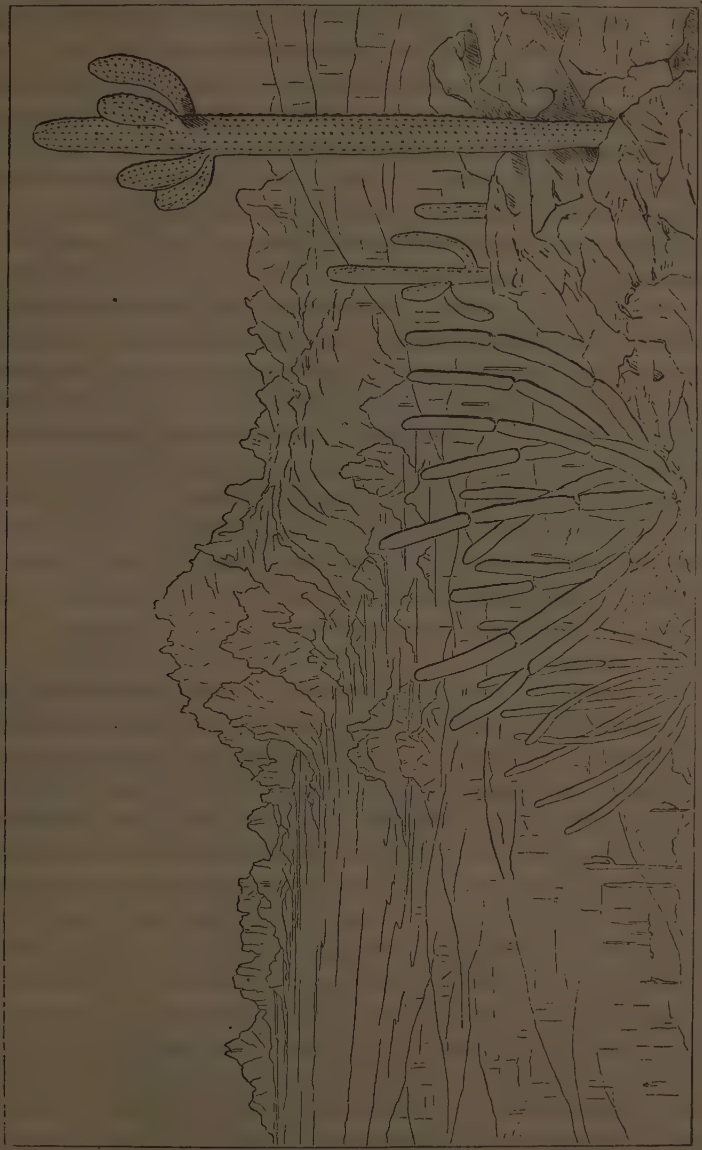
VERTICAL SECTION OF THE SIERRA DE LA NARIZ.

This sierra ranges in a slightly curved line from southeast to northwest, and joins about eight miles north of the line the Sierra del Ajo, of which it is, in fact, only a spur. A little to the north of where the line strikes, quite a depression occurs, the range here not being more than fifty feet above the drift.

A valley of about fifteen miles wide separates the Sierra de la Nariz from the Sierra de la Laguna on the north. Its petrographic character seems to be similar to the de la Nariz, having the same strike, dip, and stratification. Trap mounds accompany both sierras, cropping out along their bases to a height of thirty or forty feet above the level of the valley. There are no springs to be found about any of these mountains; holes of water or ponds, (charcos and lagunas of the Mexicans,) formed in beds of clay, are the only dependence for water, and are not to be relied on during the whole season. The surveying parties being unexpectedly fortunate in finding an abundance of water here, the sierra was called La Laguna (de la Esperanza;) it seems but an eastern branch of the Sierra del Ajo.

Northwest from the Sierra de la Nariz this latter sierra, a bold and high mountain range, is visible. As we have been told, it takes its name, (del Ajo,) garlic, from its structure, appearing as the consolidation of various branches forming a cordillera. Although composed most probably of volcanic rocks, similar to that of ranges just referred to, it is quite different in its other features. As seen from the southwest, a huge central block of metamorphic, or, more probably, igneous rock constitutes the strike side. This block, exhibiting traces of horizontal stratification, is divided into two almost equal parts by a protruding mass of rocks, which, though lithologically almost the same, show a vertical columnar structure instead of a horizontal stratification. On the sides and about the base numerous isolated and volcanic peak

tower up, but they all, undoubtedly, have the same origin. The main body of this sierra, resembling the bulbous head of garlic, has been dignified with the name of that plant. This rather hyperbolic comparison appears somewhat justified, as it refers also to the endogenous



SOUTH SIDE OF THE SIERRA DEL AJO, AND PART OF CIÉNAGA DE SONOYTA.

growth of both the sierra and the garlic. It forms a subdivide, but the separated waters unite before they are lost in the waste of sand along the Gulf coast.

A wide valley spreads out from the west foot of the Sierra del Ajo; being hemmed in on all sides by mountains, and having only one (and that somewhat obstructed) outlet, this is desig-

nated, in Spanish, as a ciénaga. As the sierra heretofore referred to strikes the eye with a dark-brown or even black aspect, on the other hand the sierras southwest, composed of metamorphic crystalline rock, (feldspar prevailing,) meet the view in a robe of glaring white, dazzling under the rays of a Sonorian sun. It is common to the traveller to distinguish these two classes of mountains as the *black* and *white*, so opposite is their general appearance. At the western foot of the Sierra Juchibabi, which bounds the valley on the south and near the old Mission of Sonoyta Chloritic slates and greenstone appear—these are, however, but local. A branch ranging north shows throughout the same light-colored feldspathic crystalline rock. The ridge east of the ciénaga is but a slight swell of the diluvial plains, and affords an open and travelled pass to Presidio de Altar.

Besides numerous deep charcos and even small lagoons in its lower part, this ciénaga is blessed with a small stream fed in its outset by a number of small springs. These springs afford a constant flow of water, which proves their deeply-seated source. The water is clear, of a bluish hue, but warm and slightly brackish. Notwithstanding this permanent supply, the little river of Sonoyta continues but about a mile as a running stream. There was a mission founded here, but it has long since shared the fate of all similar establishments of this desolate and remote region. The inhabitants now consist mainly of Papagos, who have a few miserable huts, and irrigate a small patch of ground.

The Sierra del Ajo, rising up at the northeastern corner of Ciénaga de Sonoyta, is remarkable for establishing, by a natural monument, a true boundary between the coast and the interior. In its northwestern continuation auriferous and argentiferous copper ores abound. The gold and silver product in this location is said to be sufficient to defray all expenses of mining and assaying, leaving the copper a net gain. These mines have been long known to the Papagos and Mexicans, but were not worked for want of capital and security against the Apaches. Some Californians, under the name of "Arizona Company," have now "prospected" the country between Sonoyta and the Gila. They commenced to build roads, make water-tanks, introduce labor, and, notwithstanding these initiatory expenditures, anticipate a prosperous business.

Following the bed of the Sonoyta river, a narrow but smooth pass leads to another ciénaga, which, having but little water, assumes the general aspect of the desert. The course of the Sonoyta river is traceable through it, but the water, except in two or three places, does not come to the surface, and it is necessary to dig for it everywhere during the dry season. Feldspathic crystalline mountains border also the ciénaga except on the west, where the river finds an outlet for the flood of water that may sometimes rush down its usually dry course.

The sierra partakes very decidedly, in its physiographical character, the features of the Great Colorado desert. It is a Papago name, and signifies little mountain gap or pass. Upon some rising ground in the west end of the last-mentioned ciénaga there is a settlement, or, more properly, cattle rancho, the inhabitants of which are favored with spring water flowing out in abundance from a dozen little springs. These springs come out in a line from a considerable bank, which seems to have been formed by sediment, perhaps carbonate of lime, which they themselves have precipitated. The water resembles, both in appearance and mode of issue, that of Sonoyta, and there would be in all probability no error committed in assigning their thermal and mineral properties to a common source. West of Quitobaquita the line passes over a broad ridge dipping east and west before reaching the Cerros de la Salada.

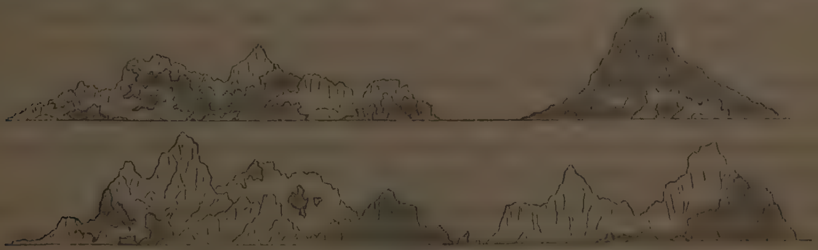
This group, like all the adjoining mountains, consists of crystalline feldspathic rock. The present structure of the Salada hills indicates a general geognostical disturbance of the relative position they must have once sustained. They vary in relative height, and the rocky parts are often covered with debris. The relative position as well as the direction of the sierras between this place and Sonoyta show a deviation from the parallelism so characteristic of northwestern Sonora.

The water of the Rio Sonoyta appears above ground for the last time near Quitobaquita. On the southeast side of the Cerros de la Salado fresh palatable water can be got in its bed by digging to a depth of about three feet. Just below, it becomes so salt that even famishing mules will not touch it. This salt water has given its name to the adjoining mountains. From this point southward the country is open, presenting to the view a bold and isolated mountain group at some distance, known as Sierra Pinacate. Its name, signifying beetle, does not seem to have reference to any peculiarity in appearance or formation. In consequence of the entire absence of water, the Sierra Pinacate is almost inaccessible; it is, however, celebrated throughout Sonora for wonderful and inexhaustible layers of rock-salt, which is said to be stored up in immense masses, arranged in diversified strata and of a variety of colors. This Pinacate, in all probability, bears a close geological relationship to the Cerros de la Salada.

West of the Salada hills a wide, waterless desert stretches out, studded with numberless isolated little peaks and a variety of mounds, composed of the crystalline feldspathic rock or igneous masses—the latter is either trapitic, amygdaloid, or porphyritic. Southward, this desert is bounded by low ridges or, rather, gradual risings of the diluvial main; north and west by bold volcanic sierras. A rugged cordillera, known as the Sierra Tule, limits this desert on the west, and breaks off what would be otherwise an uninterrupted continuation of the great Colorado waste.

There are playas near the centre of this desert plain, and sometimes just after a rain charcos of drinkable water. Towards the Sierra del Tule, there is an ascent over an immense bed of dark versicular trap, from which rise small black and white hills or mounds. These gradually increase in size and number in the vicinity of the mountains, and assume an elongated shape, with the usual bearing S.E. and N.W. Finally they unite with the latter, and form spurs of the main mountain mass.—(See outline sketch No. 58, of azimuth line.)

The black and white rocks which constitute this mountain appear in one place closely packed or pressed together; in another they shoot up as separate branches. The dip and strike with the stratification and cleavage are contorted, and in most places entirely obscured; at another



PLUTO-VOLCANIC PEAKS STUDDING THE MAL-PAIS EAST OF THE SIERRA TULE.

place again they are traccable even at a distance of a mile. This is a mountain block—the upheaved corner of a bed of feldspathic syenite or granite changed into granitic lava or regular

trachyte, containing numerous large crystals of glassy feldspar. The singular aspect of this mountain is produced by the protusion of crystalline rocks through a bed of black vesicular trap.

The morphological features of these walls of rock bear a resemblance to the ice formations of the Polar seas. Similar causes have effected similar results; there, we have the consolidation of aqueous masses; here, the crystallization of pluto-volcanic rock. Similar in outline, there are, on the one hand, ice-fields, hummocks, packs, and icebergs; on the other, vast beds of trachytic lava, contorted peaks of porphyritic or amygdaloid rocks, upheaved edges of immense beds of metamorphic masses forced upon each other—broken, crushed, and shattered—and formed over again.

The whole of both the icy and rocky world, each one floating half submerged upon an ocean—the one upon the salt waters, and the other upon the residue of a quaternary sea. The moving medium is also somewhat analogous to the masses acted upon. There are the oscillatory movements of the sea with one, and the folding of the earth's crust with the other.

That metal is to be looked for in mountains like that of Sierra del Tule is doubtful. A piece of copper ore, however, was picked up by one of the party off one of the highest—almost inaccessible—peaks. Our duties were such as would not permit of an examination for ores of any kind; yet had their been any indications of their occurrence—such as oxides and sulphates of copper or lazur and malachite—they would certainly have attracted our attention. (For analysis of piece discovered, see page 25.) This, consisting like the last-mentioned sierra of several ranges, would be more properly called cordillera.

The petrographic features of these sierras are similar, and there is not much doubt but that they originated from a common upheaving focus. This sierra is the last of the ranges traversing the State of Sonora. Westward from its crest a few rocky peaks only are visible, rising out of the diluvial main like out-posted reefs along a seacoast, and are in all probability the tops of submerged sierras. The tinajas altas, or water-holes, in the volcanic crevices of this mountain are famous; they are the principal places in the surrounding country where the traveller between the Colorado and the springs of Sonoyta may expect to find water.

After leaving this sierra, the Colorado desert proper is entered upon, stretching in an unbroken sheet of drifting sand to the foot of the California Cordilleras, a distance of about 130 miles. The distance in a direct line from the Tinajas to the Colorado is about 45 miles; about midway, there is a slight swell of the sand traversing the desert, and which may be considered an underground sierra.

Reviewing the mountain ranges passed over, we find that they invariably dip to the east, with their strike facing west; each sierra and cordillera may, therefore, be considered as one page in the great book of creation. Few of them have been fully opened so as to permit a satisfactory reading of their pages; whilst their greater number still remain closed, with just one edge turned up. Our belief is, that when the time for further revelations come, the axis of disturbance will develop itself in the eastern base of the California Cordilleras, and these mysterious sheets will be turned from west to east.

The sierras Santa Cruz, Pajarito, and Santa Barbara, have disclosed a part of their geological history, while others, especially those on the confines of the desert, have hardly commenced to do so.

Earthquakes are not uncommon in the basin of the California Gulf. There are two solfataras now known at the eastern foot of the south California Cordilleras, both still in activity; and

the lower Colorado is constantly changing not only its bed but also its numerous bends. Below the mouth of the Gila there is but one place where the river remains unchanged, which is so remarkable a fact that the navigators of this river named it the "Permanent Bend."

Considering such facts, we cannot doubt that the regions here spoken of have not yet passed through all the phases of their destiny. We do not, however, believe any general and violent catastrophe indispensable for further geological developments. A long continuance and perhaps imperceptible rising of the country, a simple increase of elevation, and especially an enlargement of the angle of grade by which the horizontalism of the quaternary main would be disturbed, should it become subjected to these forces, would aid the torrents of the mountains and the sweep of ærial currents to clear the surface of the country from its desert burden.

CHAPTER V.

PHYSICAL AND GEOLOGICAL DESCRIPTION OF THE COUNTRY FROM THE INITIAL POINT ON THE PACIFIC TO THE JUNCTION OF THE GILA AND COLORADO.

The data on which these results are based are derived from personal observation and collections continuously made during my stay in that region from July, 1849, to March, 1851. This period was variously occupied in different sections of this region, including an interrupted residence in the vicinity of San Diego; an expedition of three months' continuance to the mouth of the Gila River; a land journey up the Pacific coast as far as Monterey; a residence during the fall and winter months of 1850–'51 at the Mission of San Luis Rey; together with various minor excursions to the mountains east, north and south of San Diego.

The region of country thus covered by my observations includes portions of territory lying between 32° and 36° N. latitude and 114°–121° W. longitude. The district, however, to which my attention was mostly confined is indicated on the accompanying geological map, and popularly known under the title of Southern California.

The separate heads under which I propose to embrace the general information pertaining to the subjects assigned me are—

I.—*The general physical features of country.*

II.—*Geology and mineral productions.*

III.—*Botany.*

IV.—*Agricultural capacities.*

I.—THE GENERAL PHYSICAL FEATURES OF COUNTRY.

The most marked external feature which serves to give character to the region under examination is seen in the occurrence of a mountain range parallel and in close proximity to the ocean, presenting in its various elevations and the differences which characterize its two slopes (eastern and western) a great diversity of scenery within a small compass of territory. The range itself, in its geographic relations, must be regarded only as an inferior link in the great mountain chain extending along the entire northwest coast to the extremity of the California peninsula. To the part at present under consideration the local but not very precise term of the Cordilleras of California has been applied.

Directing our attention to this portion of the mountain range, considered as a whole, it will be remarked that, while the general direction of the range is parallel to the coast, this feature is worked out in detail so variously that it would be difficult, from a single point of view, to decide on the true direction from noting the supposed axis of greatest elevation. This is, perhaps, owing to a peculiar feature of the range, which, instead of consisting of continuous ridges or *sierras*, as they are termed, are made up of an irregular series of rounded or ridge-formed

peaks, sloping gradually towards each longitudinal extreme, with their more or less tapering spurs interlocking with those of adjoining ridges, but scarcely ever in a continuous line.

This view of the range will serve as a useful key to explain many of its peculiarities. Thus, as one fact in connexion with the general features of scenery, it will be noticed, that though the bareness of vegetation would seem to favor extensive views, they are seldom, even from the higher points, of that commanding character such as may serve to give a true idea of the elevation attained, or to strike the mind with those ideas of grandeur elsewhere connected with wide-spread mountain scenery. The horizon is, in fact, shut in, and the view confined to a limited sphere, by the varied direction of these mountain spurs. Roads and passes are also readily found, and routes can be modified with comparative ease by selecting the interlocking spaces to pass from one range to another, or by crossing spurs at their lower depressions.

Another fact connected with this character of the range is a marked tendency in the main valleys to assume a basin shape, apparently encircled by mountains, and fringed on all sides by branch valleys, affording a choice of travelling routes in every direction. We also frequently meet with upland plains of a similar character, where the more extended view takes in distant mountains, in which, though a more determined general direction of the range is apparent, the approach to a basin feature is not lost.

Connected with the same general cause, streams find their way by very devious courses, and on the western slope, particularly, are seldom followed in any direct line of travel.

In reference to the two slopes of this mountain range, an important point connected with their distinct external features is to be noted in the fact that the axis of greatest elevation, or the true divide, is much nearer to the eastern than the western base. Thus, supposing the mountains to have an average width of 60 miles, the centre of this line would invariably fall far on the western slope, the real water-shed being pretty constantly marked within ten miles of the eastern base, thus leaving a proportional difference between the length of the two slopes of five to one at least; hence, as a natural consequence, the eastern slope is more abrupt and precipitous, the western more gradual and circuitous; the streams of the former dash down a limited descent, and are soon lost in the absorbent debris at the base; the streams of the latter, flowing more leisurely, and drawing as tribute in their winding course a more abundant supply, frequently embody sufficient force to reach the ocean.

Confining the attention more closely to the Pacific or western slope, we are led to observe in its wider dimensions that it is made up of quite a number of parallel minor ranges, comprised in the general series, forming intervening depressions, and marked off by spurs, in the above-mentioned basin-shaped valleys; towards the summits these valleys are more contracted in breadth, and attain wider dimensions as you approach the coast. At the higher elevations, the mountain sides are usually bare and rocky, but the immediate summit assumes a more verdant character, being clothed more or less with pine and Alpine oaks. The ranges adjoining the coast are smooth in outline, slope up gradually into vertebrated ridges, and are covered with a dense, brownish shrubbery, giving a singular, smooth aspect to their distant outline. Moisture is more abundant and the streams more copious towards the higher elevations, while the wider coast valleys, unfed by perennial streams, are, during the greater part of the year, destitute of running water, the issue from occasional springs becoming speedily evaporated in the dry atmosphere.

These different ridges vary somewhat in geological structure, and, as we shall have occasion to notice hereafter, serve to give an additional variety to the mountain scenery. However viewed, nakedness is the prevailing character, the exceptions being few and far between.

The summit ridge, attaining a variable height above the sea of 3,000 to 5,000 feet, presents in its wintry covering of snow, and its richer verdancy of summer growth, some of the finer features of California scenery. Without possessing a marked Alpine character, it approaches it in a sparse growth of pines, and other coniferæ; while the frequent fogs bathing its sides favor the growth of lichens and mosses almost unknown in the lower regions, except in a few evanescent forms during the rainy season.

The view to the west takes in the bold outline of treeless ranges stretching in a dim line seaward. Looking towards the east, the less obstructed view traces the line of diminished vegetation, plainly and somewhat abruptly marked, in going downward on the steep slope. Irregular mountain peaks, and ranges of a dull, ashy color stand out in view in close proximity, and below all stretches the brown plains of the desert, extending to the hazy marked line of the Colorado river.

Descending from the summit westward, you pass down luxuriantly grassed valleys, edged with scattering pine and oak groves, and watered by cold, perennial streams, until an abrupt descent to a lower level brings you again into wider basin-shaped valleys, bounded on all sides by rocky ridges. The streams spread out into low grassy or sedgy marshes, and the pine growth gives place to the lowland oak, with its peculiar undergrowth. Continuing thus by a series of gentle swells and abrupt descents, you pass almost insensibly the different ranges, till the smooth, brown outline of the coast range indicates your proximity to the sea.

In the summer season you wind down broad valleys, marked by the dry, pebbly beds of winter streams; herbage is dry and wiry, and water confined to a few willow-shaded marshes or isolated springs. Opening on the sea, you traverse dry moorland hills, dropping down to the sea-level in the bed of some wide, sandy valley, which, with its sides bounded by precipitous walls of coarse sand and pebbles, finally spreads out into wide saline flats, cut up by tide estuaries, and terminates on the ocean beach.

Proceeding from the same summit ridge in the opposite direction (eastward) from its pine fringed heights and rich green sward, you drop by a steep descent into pent-up valleys bounded by ashy-colored mountains. The streams which flow in the upland ravines are soon lost in their thirsty beds. The valleys near their exit from the mountains slope in a regular plane, covered by wide and dry beds of streams. Occasionally the passage of an irregular mountain chain is marked by a rude defile, cutting through mica slate, or highly micaceous granite. Thus winding with occasional passages over ridges of the same character, flanked with rough pebbles, the desert opens before you, its table-land being generally gained by a steep ascent from the deep bed of some dried up stream, along the course of which the geological tertiary formation is strongly marked in thick layers of marl or sand, surmounted by a varying bed of rounded pebbles.

Over the desert waste, furrowed occasionally by the dry sandy beds of rain streams, you pass insensibly down till the lake formation of "New River" comes into view. Here the soil acquires a sedimentary character; fresh-water shells are scattered here and there. The immediate lake edges and lower depressions are bordered by a growth of mezquite, while, in its

proper season, large patches of *annual grama grass* relieves the desert of its barren aspect, and transfers the mind to scenes of neatly trimmed pleasure grounds set off with verdant shrubbery.

The next stretch mounts again to the pebbly strewn table-land of the desert, from which you descend further by the steep sandy bluff which bounds the bottom land of the Colorado river.

STREAMS AND WATER-COURSES.

A consideration of the character of the various streams and water-courses in this region belongs properly to the view of its external features, and derives especial interest from the intimate relations they sustain to climate and agricultural resources. On the western slope the various streams, each draining a very limited area, are remarkable more for their number than their magnitude. Having their main sources near the mountain summit, they pursue their tortuous course towards the sea, following all the irregularities interspersed by the separate mountain ranges and their projecting spurs. By these devious courses the descent is finally accomplished without occasioning falls or cascades, which are so commonly associated with mountain streams elsewhere.

Their volume being necessarily dependent on the supply from local rains, they generally attain their greatest bulk towards the close of the rainy season, when the melting snows at their sources combine with frequent showers below to swell their volume. As the dry season advances they gradually contract their dimensions, till in the month of July most of the streams near their mouth become absorbed in their porous sandy beds. The exception to this general fact is seen only in those streams which, having their sources in the higher mountain ridges, receive a sufficiently constant supply to exceed the amount lost by evaporation.

The drying up of the stream beds is a gradual process, necessarily modified by the comparative dryness of the atmosphere, as also by the relative absorbent or retentive character of their beds.

The point at which water ceases to flow is quite variable; its more usual upward limit being marked at or near the passage of the stream from the first rocky ranges into the Tertiary formation. The point, however, as before stated, is by no means a fixed one; thus, during the night it extends further downwards than in the daytime; in cloudy weather, for the same reason, its course is more prolonged than under a clear sky. In the stream beds themselves, however dry, water is generally found a short distance below the surface.

The descent of these streams in the rainy season may be either a gradual process in the progressive saturation of their sandy beds, or the saturation being accomplished by previous showers, the irruption may be sudden. A fine example of this sudden appearance was observed in the San Diego river, in December, 1849; when, after a rainy night, by which its sandy bed was completely saturated, the upper stream suddenly appeared in the form of a foaming body of water, moving onward at the rate of a fast walk, curling round the river bends, absorbing the pools, and soon filling its shallow bed with a brimming swift current.

An instance of the more gradual descent was seen on the following season, December, 1850, when, from the absence of local rain, its downward progress was slow and interrupted.

The facts connected with this supply of running water seems to deserve particular attention in this region, where its presence or absence is synonomous with barrenness or fertility.

The streams of southern California are, in truth, the life-blood of its agriculture, and the means to be adopted to extend this supply can only be efficiently based on a clear understanding of all their separate relations, both as to atmospheric conditions and geological structure. In many of the old mission establishments extensive lines of masonry were constructed, by means of which the streams were tapped a short distance above their place of sinking, and a vigorous irrigating supply conveyed to the lower portions of the valley, thus rendering productive lands otherwise useless for all the common purposes of cultivation.

It is therefore in the true character of these streams—with reference to their sources, their beds, the elevation and geological structure of their banks and bottoms—that we are to look for the fairest general idea of the agricultural capacities of this region.

But it must further be remarked that it is not to these mountain sources alone that we must look for the needful supply of water; occasional springs in the lowest portions of valleys frequently furnish a constant flow sufficient to meet the demands of cultivation over a limited area.

Thus, the extensive mission of San Luis Rey, proverbial for its vertility, depended almost entirely upon such sources of supply. Similar examples in other parts, though rare, may furnish useful indication, in directing the location of artificial means of supply, by the construction of Artesian wells.

Referring to the character of the streams on the eastern mountain slope, we have before noticed their abruptness, also the rapid diminution of volume which they undergo in their steep descent. The excessive dryness of the atmosphere, and the more absorbent character of the strata through which they pass, serves to exaggerate all their peculiarities, as compared with the opposite slope. The streams, equally as vigorous at their sources as those of the other slope, are quickly absorbed in their course, and none at any time acquire sufficient volume to be entitled to the name of river affluents. Thus, though the existence of wide and deeply cut stream beds show the occasional agency of powerful streams, derived from the rapidly embodied force of copious rains, yet their rare occurrence and short continuance only serve, in the main, to give an exaggerated feature of barrenness and desolation to a region where, during the greater part of the year, scanty supplies of water are only attainable from stinted and unwholesome springs.

The point at which water ceases to flow is extremely variable, and exhibits a singular intermittent character: thus, in the morning you may cross over quite a large brook, and at the same place, by noon, find it entirely dried up, to show itself again when the diminished evaporation, at night, allows the ground, instead of the atmosphere, to receive its aqueous tribute. Often you meet with streams, near the lower mountain slope, present at one point of their course and absent at another, thus constantly varying, according to the relative absorbent or retentive character of their beds.

On the desert plains, the stream courses are marked by wide beds, with more or less abrupt banks, cutting through strata of sand, marl, or coarse gravel. Near the mountain base they exhibit steeply inclined plains, strewn with a variety of rounded and angular pebbles.

In the re-entering angles, formed by the irregular projection of mountain spurs, these plains often attain an elevation of nearly one-half the mountain height, and are taken advantage of in the selection of passes.

But the point of all others which has attracted most attention, in reference to the distribution

of water on this desert plain, is to be noted in that singular feature, to which the name of "New River" has been applied by the Californian emigrants.

The idea naturally conveyed by this name is that of a running stream, arising in the desert and flowing towards the Colorado river, but its true character is quite the reverse; the current itself, which is by no means constant and at all times irregular, is in the opposite direction, or from the Colorado, while its bed, instead of exhibiting the features of a regularly washed stream bank, shows only a chain of lagoons or marshes irregularly connected, and often spreading over extensive tracts, or at other times contracted within narrow beds. Its novelty, moreover, is sufficiently disproved by the presence of heavy mezquite growth, and other plants and shrubbery usually associated with the presence of water in this region. Indeed, all the singular features in the case are now sufficiently accounted for, in the ascertained fact (first suggested by Major Emory from barometric observations) of the existence of a natural depression, at this point, below the level of the Colorado river at high water. The connexion between the overflow of the one and the appearance of the other has been frequently observed, though the exact course of this connexion has not yet been traced out. Still, all the facts in the case derive their full explanation by referring it to this peculiarity of the Colorado river, which, seeking an outlet for its swollen waters, spreads them in fertilizing deposits to such a great distance from its usual bed.

LAKES AND LAGOONS.

Mountain lakes are of very rare occurrence in any part of the region under examination. The only body of water that I am acquainted with really deserving the name of a lake, is found on the western slope of the mountains, near the parallel of 33° 30′ north latitude, and some twenty-five miles distant from the ocean. It is about five miles long, by from two to four in breadth. It has no outlet, and its waters are consequently brackish. It is also apparently shallow, and exhibits along its banks marks of recent and continuous recession, plainly indicating a gradual exsiccating process. What adds to the interest of this latter fact, is the explanation it seems to offer of the original condition of some of the more fertile basin valleys, which exhibit all the characters of a lacustrine origin, to which they now owe, in a great measure, their fertility. A fine example of this may be noticed in the rich and extensive valley known as the San Bernardino. It is seen encircled by high mountains on all sides, and seems to have derived its subsequent drainage by the Santa Anna river, which is now observed passing through an elevated range of tertiary mountains towards the ocean.

On the desert plain of the eastern side of the mountains, report speaks of one or more extensive salt lakes, but no opportunity was afforded for a personal examination of their true character or extent. The fresh water lakes and lagoons belong to the "New River" formation, which has been sufficiently noticed above.

II.—GEOLOGY AND MINERAL PRODUCTIONS.

Directing the attention more especially to the geological structure of this region, we have to consider the same mountain range, in its line of greatest elevation, constituting a central axis from which we may trace on each side the diversities that characterize its extended flanks.

By reference to the accompanying geological map and sections, *three* main facts will particu-

larly claim our attention, and serve at the same time as the most natural division by which to unfold the entire subject.

1st. The great preponderance of crystalline metamorphic granite pertaining to the older paleozoic series of rocks.

2d. The entire absence of any member of the lower paleozoic, or secondary rocks, in their regular stratified character.

3d. The existence of extensive Tertiary deposits, forming a more or less extended flank, on each side of the m untain range.

1st. In reference to the preponderating granite formation, as exhibited in the central axis, and main development of the mountain range, we shall notice a considerable diversity of form and structure, but all evidently pertaining to the same general formation of metamorphic rocks in their different exposures. Illustrative specimens are characterized by Professor Hall in the accompanying list, to which reference may be had for special characters.

The central axis is represented by a somewhat variable mottled granite, composed of various proportions of *quartz*, *feldspar*, *mica*, and *hornblende*, frequently containing imbedded crystals of *tourmaline*. The exposed mass varies greatly in the degree of aggregation of its component materials, assuming in some places a close sienitic texture, while in others a larger proportion of feldspar renders it more readily decomposable by disintegrating causes—its exposed face easily crumbling into a coarse, granitic sand.

At other points the preponderance of mica, confusedly mixed in large scales, serves to give a very irregular form to the external rock-exposures.

Belonging also to the same series, we find, particularly on the eastern side of the range, mica and talcose slates associated with quartz veins.

The irregular rocky range immediately adjoining the coast, and also probably composing the numerous rocky islands extending at variable distances seaward along the same line from northwest to southeast, present a distinct form of eruptive rock, described by Professor Hall as "*greenstone, with soft chloritic spots, or blotches*," and "*porphyry*, or *porphyritic greenstone*." This character of rock forms the first extensive range of mountains east of San Diego Bay, and attains an elevation in some of the higher peaks of 2,500 feet above the sea.

Further to the north, in the vicinity of San Luis Rey, several isolated peaks exhibit a basaltic structure, weathering into peaked domes, with abrupt columnar faces. Professor Hall considers all the rocks of this series as of quite recent origin, compared with the central granite series above mentioned. As sustaining this view, we observe further north, in continuation of this range, near Santa Barbara, evidences of disturbed Tertiary rocks associated with similar or more recent igneous exposures.

The isolated mountain peaks and ranges adjoining the Colorado River exhibit a sienitic texture, which, by exposure to the dry atmosphere, acquires a deep brown, polished face, giving a peculiar and forbidding aspect to the bare mountain scenery.

These sienitic rocks are frequently associated with gneiss, exhibiting a very distinct stratified character, occupying a position external to the adjacent igneous rocks.

The immediate junction of the Gila and Colorado Rivers is marked by a singular geological formation. It is composed of an irregular series of rounded knolls, attaining a height of thirty to eighty feet above the river level.

The summit and sides of these knolls are strewn over with the erratic fragments which pertain to the continuous desert formation, and which conceal the central nucleus, except in the deep cleft made by the passage of the Colorado just below its junction with the Gila. At this point we see the central nucleus forming an irregular breccia, composed of variously sized blocks, frequently massive. The rock is a form of greenstone, streaked with epidote. The cementing material is apparently derived from the natural decomposition of the contained rock. On the western side, near the level of low water, there is an underneath exposure of a dark-colored mass, composed of epidote, with talc—the latter being occasionally granular. This material is seen shooting upward into the superincumbent breccia in the form of veins, and would seem to hold some close relation with the disturbing cause below.

The external features of this singular formation we have endeavored to represent in sectional sketches.—(See part 1, pages 128, 129.)

The Tertiary formation.—The Tertiary formation which flanks the mountain range on the west extends to the Pacific coast, forming a belt of variable extent and thickness, and composed of various stratified deposits.

The strata adjoining the sea occasionally presents abrupt ocean bluffs, washed by the waves at high tide; through the same formation the various streams cut their way, forming deeply trenched valleys. The strata thus exposed in the sides of valleys exhibit a slight dip toward the sea, and are seen to be composed of alternate beds of coarse sand, clay, or marl, with occasional beds of interstratified pebbles, all smoothly rounded, and variable in size.

SECTION OF LIGNITE BLUFF NEAR SAN DIEGO.

A. Coarse, feruginous sand, with occasional interstratified pebbles, weathering very irregularly into fantastic shapes, forming miniature peaks and ridges.

B. Coarse, white sand, in even, horizontal strata.

C. Drab-colored sandstone.

D. Fine-grained sand, varying in color from buff to light-gray, containing thin seams of sulphuret of iron.

E. Tough clay, containing an irregular seam of lignite, with smaller portions of mineralized bitumen.

In the vicinity of San Diego, and plainly exposed in the steep bluffs which bound the lower part of the river valley at this place, is observed a distinct fossiliferous layer, having a thickness of about thirty feet. Its lower members, resting on micaceous sand or clay, are not more than twenty feet above the present sea level.

The contained fossils are made up mainly of silicified casts of marine shells, imbedded in a calcareous medium of more or less close texture. The individual forms of fossil species are quite numerous, though the number of distinct species is not great; the most abundant and widely spread is a species of *Turritella*.—(See Plate No. XIX, fig. 8.)

This formation is distinctly traceable at various points up the coast, and in the neighborhood of Santa Barbara is seen to form mountain masses. Wherever noticed, it is overlaid by various sandy layers, forming an upper capping of very variable thickness.

The irregular layer of interstratified pebbles, so frequently seen in hill-sides, seems hardly capable of being referred to any distinct place in the general Tertiary series. Their most abundant occurrence, however, near the mouths of valleys opening on the sea, sufficiently indicate that they are derived from the combined agency of river transportation and tide-washing—having attained their present position by subsequent land elevations.

The junction of this Tertiary formation with the adjoining granite or igneous rocks is seen in a general thinning out of the former, which, at last, barely mantling the protruding rocks, is blended with the result of present decomposing agencies.

Natural terraces and table summits.—Another interesting geological feature, observable in the post Tertiary strata adjoining the coast, is the existence of natural terraces and table summits, of various elevations, and their evident connexion with ancient sea levels—thus indicating successive periods of land elevations.

A series of at least three of these terraces is distinctly noticeable near the initial point of boundary on the Pacific.

The highest of these is exhibited in that striking landmark appropriately named "Table Mountain." Visible, far out at sea, and attaining an elevation of not less than one thousand feet above the present sea level, it presents a distinct outline of abrupt slopes terminated by a regular flat table summit. As it now stands in its isolated character, and not far from the sea beach, it appears to be altogether unique, though, doubtless, more extended and accurate observation of height and situation would show its connexion with some of the higher terraced elevations adjoining the interior mountain slopes.

The next step in the descending series is represented in the average level of the post Tertiary bluffs and hills near the coast, say at a present elevation of two hundred to four hundred feet above the sea. The irregular character of the deposit, at various points, and the evidence of long-continued denuding influences, have necessarily obscured the general level; or, as we may suppose, the land elevation at this period was itself irregular or alternating with periods of depression. It may further be remarked, as substantiating this latter view, that the deposits here exhibited are those most abundantly characterized by the presence of transported rounded pebbles, irregularly distributed, as we have seen, along the course of valleys of denudation.

The third well marked terrace formation in the descending, or more recent series, occurs in close proximity to the present sea beach, and is characterized by a more alluvial deposit, and also the first appearance of recent marine shells, strewn irregularly over its surface in comminuted fragments. A fine example of this formation is met with where the initial point of boundary on the Pacific is marked by the first monument. Attaining an elevation of forty to fifty feet above present tide water, it presents a steep slope seaward, and extends in quite a regular terrace to the adjoining broken hills, before noticed, as constituting the middle terrace formation.

This last step in the series presents in its organic remains, and more alluvial character, an approach to the present alluvial tracts of this region.

Further north, where, from the western bend of the coast the Tertiary belt acquires its

broadest dimensions, we have apparently the formation last considered represented in those extensive plains which, extending inland from the sea often several leagues, give character to that section of country by increasing its agricultural capacity.

The commencement of these plains on the south may be seen, by reference to the map, to correspond with the greater development of the Tertiary formation, both in extent and thickness.

Thus to the N.E. of San Juan Capistrano the Tertiary deposits form an elevated mountain range, attaining a height of two thousand feet or more above the sea. Here, also, are exhibited the first signs of internal disturbance in abrupt and variable inclinations of the Tertiary strata.

As the necessary result of all these conditions we have a more abundant supply of material, under the natural denuding influences, for the formation of the lower terraces, or the plains, under consideration.

Some of these plains, encircled by higher Tertiary hills, represent in outline beds of extensive sea bays, of a previous era, now, by the elevating agencies at work, converted into their more attractive land features. A fine example of this latter fact may be noticed on the accompanying map as the "Santa Anna Plain."

Desert formation.—The corresponding Tertiary formation on the eastern side of the mountains must now claim our attention. And first, it will be remarked, in contrast with what we have noticed on the opposite Pacific slope, that the line of junction between the crystaline rock and the Tertiary belt is more distinctly marked.

The character is well exhibited where the stream courses from the mountains enter the Desert plains. They are there seen cutting their way through the Tertiary strata and presenting deep vertical sections of their stratified deposits, consisting of marls, sands, and clays, with a very constant accompaniment of stratified pebbles, the latter of greater or lesser thickness, and forming the most usual upper capping, which constitutes the table summit of the Desert plateau.

It is in the marl and clay deposits that gypsum makes its appearance, being frequently washed out along the edges of the steep bluffs in the form of shining flakes of selenite. Here, also, occur the first marine fossils found to characterize the formation, including species of ostrea.

This marl formation, thinning out to the eastward, gives place to coarse sandy layers of great thickness; thence forming the exclusive substratum of the desert, and extending to the table bluffs, which bound the alluvial bottom of the Colorado river. In this last situation it exhibits a perpendicular wall 60 feet or more in height, overlaid by pebbly deposits, having an average thickness of 20 feet, more or less. These pebble deposits are in this situation frequently cemented by a calcareous medium more or less compact, and occasionally forming a close cretaceous conglomerate.

It is in the geological features thus sketched that we can best indicate the true desert character of this region, covering a vast extent of country, and forming the plateau through which all the rivers of this region take their course. Its deep porous layers rapidly absorbing the waters of occasional heavy showers by which it is visited in the latter summer months, it spreads forth at other times an arid waste often under a burning sun. The wonder is that vegetation in any of its forms can procure the elements for a stinted growth.

The further relation of these strata to the supply of water for the use of travellers is of great

importance, and may be briefly alluded to here. It was formerly supposed that no natural reservoirs of fresh water sufficient for the supply of men and animals existed over the entire distance of 80 miles, from the mountain base to the Colorado river. The subsequent discovery of extensive depressed areas, as that constituting "New River," retentive both of rain water and river overflows, has materially shortened these "dry stretches," as they are termed, especially in certain seasons. Due to the same general cause, depressed areas, that have no connexion with flowing water, are the salt lakes of greater or less extent; the degree of saline impregnation necessarily varying according to the amount of aqueous supplies from local rains. The water, however, is rarely, if ever, suitable for drinking purposes.

Even on the higher upland plateaus water is occasionally found in the beds of shallow streams, where the product of recent rains is retained by a clay substratum, the upper sandy layers serving to check the evaporation; but such uncertain sources cannot, of course, be safely depended on during the greater part of the year.

The practical question arises, whether permanent water can be obtained by piercing the coarse sandy layers to a sufficient depth to reach a still lower impervious stratum? As bearing on this question we may cite the irregular character of the argillaceous beds, as seen in various exposures of the lower strata. This irregularity of strata indicates the great probability of finding lower basins of water of considerable extent and capacity connected with sources of supply sufficiently elevated to flow over the surface at the point of excavation.

Still another important question would come up, whether the water reached by permeating through such a depth of saline soil would not be so much impregnated with saline matters as to be unfit for use? But these are questions to be determined by direct experiment, and not by theory.

The "New River" formation, in a geological point of view, must, as we have before remarked, be regarded only as a natural depression in the tertiary series, having a direct connexion with the flowing water of the Colorado river. Its original lacustrine character is sufficiently seen and limited by the presence of fossil fresh water shells, including species identical with those now found living in lagoons adjoining the Colorado. Among these we notice *Planorbis*, *Physa*, *Anandorita;* and besides these a small univalve near *Ressoa*, quite abundantly scattered, and often drifting in small heaps over the alluvial sandy tracts which adjoin the lower depressions.

The further relation of these facts to vegetation and agricultural capacity will be alluded to elsewhere.

MINERAL PRODUCTIONS OF SOUTHERN CALIFORNIA.

The inferences to be drawn from the above geological sketch, as regards the actual or prospective mineral products of this region, may here be properly summed up, following out the same general order as before laid down.

1st. The preponderance of the crystalline granite rocks, constituting, as we have seen, the great body of this mountain range, is unfavorable to the existence of extensive or valuable mineral products. Neither does this view seem at present likely to prove erroneous by the recent impulse given to mineral discoveries on this coast.

Many persons, arguing solely from the general similarity of features between certain sections

in this region and the gold district to the north, have supposed that an equally diligent search here would yield a like reward to the explorer.

Nothing, however, has yet been brought to light to substantiate this view. The washing of the different stream beds only shows the existence of iron in the form of black sand, and no traces, or very indifferent ones, of the precious metals. This absence of metals we should naturally expect where the crystaline rocks prevail. It is on the eastern slope of the mountains, where talcose slate makes its appearance, with accompanying quartz veins, that we have most reason to expect a correspondence with the gold district of the north. Still no discoveries have as yet, pointed to any valuable result; the quartz veins examined exhibit a very uniform thickness of about 12 inches, and maintain a direction nearly north and south, without showing any disposition to form branches; all of which circumstances must be considered as unfavorable to mineral productions.

It must be left to future exploration to determine the true value to be given to the mineral indications of this district.

The often reported rumors of rich copper deposits in the vicinity of San Diego I have not been able to trace satisfactorily to but one certain source. This locality occurs at some distance south of the boundary line, near the Rancho Guadalupe. The spot itself I have never visited; but authentic specimens shown me exhibit a moderately rich copper ore, composed mainly of *green malachite*.

Such a class of minerals we may reasonably expect to find in connexion with the extensive range of greenstone porphyry adjoining the coast.

There is no satisfactory evidence of the existence of silver ore, or of quick-silver, in the district under examination.

2. The entire absence in this region of any of the forms of stratified rocks comprised in the older paleozoic or secondary period, serves to limit still further the prospective mineral wealth of this district. It excludes at once the idea, which has frequently been in vogue, of the existence of *coal* belonging to the carboniferous period. All the rumored reports of its discovery which I have been able to trace are referrible to certain forms of tourmaline, or more commonly to the existence of lignite or *mineral asphaltum*, so generally associated with the tertiary strata.

3. The mineral products pertaining to the tertiary formation worthy of special notice are but few. On the Pacific coast we have to include the various forms of mineral bitumen, a form of *Tertiary chalk*, together with various other *alkaline earths*.

The mineral bitumen is quite extensively scattered over a large portion of the Tertiary district. It occurs in most abundance where this formation acquires its broadest and thickest dimensions, and is connected more or less with igneous disturbance. In the neighborhood of Los Angeles it occurs in the form of what are popularly termed "pitch springs." In such localities, it is observed issuing in the form of a tarry liquid, becoming hard and of a deeper color by exposure to the air. In this latter form it resembles closely the pitch of commerce, and is applicable to similar uses. In the vicinity of San Diego it is found in the form of irregular patches, spattered over the sand rock, washed by high tide. It is also frequently met with in an erratic form, being silted up by the waves at various points along the ocean beach.

The more abundant product of the bitumen springs, in the vicinity of Los Angeles, is principally in use for the sheathing of roofs, as a protection from rain. In the rough state in

which it is employed, however, it has little to recommend it on the score of neatness, presenting under a hot sun a constant dripping from the eaves, disagreeable to the smell, and disastrous in its effects on broadcloth and beaver. At the same time, becoming thin, it requires frequent re-application, and in the cold rainy season is liable to crack, giving rise to sudden leaks. An improvement in these respects might doubtlessly be made, by forming a mixture with some other material, which may serve to add to its solidity without impairing its useful retentive properties. The material might also be used in many places in the construction of aqueous reservoirs, for retaining the product of rains during the wet season. These being located at sufficient height to serve the purposes of irrigation, might thus be made the means of redeeming valuable tracts of land from sterility.

Still further, as an ingredient in the manufacture of sun-dried brick, it promises to come into extensive use, furnishing, at the same time, an almost imperishable article, and admitting of extended useful application in the construction of buildings and fences, with a great saving of bulk of material as compared with the old fashioned "adobe."

In collecting this mineral bitumen for the uses above enumerated, pits of greater or less depth are sunk in the vicinity of the bitumen springs, to which the issue is conducted. This becoming hardened by exposure to the atmosphere, acquires sufficient solidity in cold weather to render it fit for transportation.

Connected, probably, with the same bituminous formation, we find frequently exposed in the sides of ocean bluffs irregular seams of lignite associated with the sands and clays of the Tertiary deposites.

The purer forms of this mineral, at times, closely resemble in external character the bitumens above mentioned, though having a more distinct mineralized structure. It is usually associated with clayey shales more or less bituminous, and frequently marked with obscure vegetable impressions. Fossil remains of lizard's teeth are also, according to the examination of Dr. J. L. Le Conte, found associated with this formation. The lignite never shows itself in any abundance, and neither the article itself or the character of the strata would warrant us in regarding it of any economical importance.

It is to this source that most of the reports of the existence of coal in the vicinity of San Diego have been referred; a brief statement of the above facts is sufficient to show their unfounded character.

The general appearance of this lignite formation, in reference to the commonly associated strata and their comparative thickness, is represented in the accompanying sectional sketch of *Lignite bluff*, as seen at the mouth of Solidad valley, above San Diego.—(See section, fig. 162.)

A third mineral product pertaining to the Tertiary formation, on the coast, is "a highly aggregated calcareous deposit, resembling chalk;" this article is found not generally distributed, but in irregular beds, sometimes of considerable thickness. In the absence of all other limestone materials, it is used for conversion into a weak form of quick-lime; and it is also from some other associated alkaline properties employed in the making of soap.

In the tertiary formation on the eastern side of the main mountain range, the only mineral productions worthy of note are gypsum and common salt. The former is quite abundantly exposed in the marl strata, near the mountain base, where it may probably be found to form

extensive beds. In its present inaccessible position it gives little prospect of being sought or applied to any useful purpose.

Common salt, as before stated, is found along the edges of salt lakes on the Desert. In these situations it is said to be procured with ease by superficial digging, and of very pure quality.

For more detailed information in reference to the mineralogical character of the prevaling rocks and earthy deposits, reference may be had to the list of geological specimens, prepared by Professor Hall, of Albany, New York, which will be found in his report.

The geographical boundaries of the various formations, with their relative developments, are indicated in the accompanying map and sections.

NOTE BY W. H. E.

Assistant Arthur Schott passed over the tract of country described in Chapter V. His geological view of it is so similar that I do not consider it necessary to publish it; but I give an extract from his report, which contains some interesting facts in reference to the changes which have taken place in the Great Desert within the historical period, and some general views, which I think are sound, and are applicable not only to the Desert where it is crossed by the Mexican boundary line, but that vast region of desert country which lies to the north of the line, and which spreads out and probably attains its greatest breadth in the region of the Salt Lake.

Whatever may be the opinions of persons interested in the more northern lines of travel and projected railway routes to the Pacific, we cannot shut our eyes to the existence of this Desert on any line of travel south of the South Pass, in north latitude 42°. I am also of the opinion that this Desert, within the limits of the United States, is narrower and more easily passed over by a railway immediately north of the Mexican boundary than on any parallel to the north of it. An attentive perusal of the report of Governor Stevens will show that even north of the South Pass vast tracts of arid and desert regions were encountered in the same longitudinal zone, which, added to the rigors of the climate, form an almost insurmountable barrier to the project of opening through those regions any great highway of travel, either by railway or wagon road, between the Atlantic and Pacific States.

The full power of the government has been directed towards establishing posts and opening these northern lines of travel; yet we have, within the last few months, seen Fort Laramie, Fort Pierre, and, I believe, even Fort Kearny abandoned by the government, owing to the absolute sterility of the soil, and the impossibility of inducing settlements, or raising even vegetables necessary for the use of the troops.

The records of the Quartermaster General's office show the long continued efforts which the government have made to establish these posts as *nuclei* for settlers, and the utter failure to induce settlement, and make the surrounding country at all conducive to the support of the troops. The idea of carving out States from that portion of the American continent between parallels 35° and 47° and the 100th meridian of longitude and the crest of the Sierra Madre is a chimera. The example of the Mormons is often cited to prove the capacity of the country to sustain population. They occupy an oasis in this great Desert, and their power to sustain even the population they have is by no means established beyond a doubt. On two occasions the grasshoppers were very nearly eating them out and producing a famine; and I am very sure, if it were not for their peculiar institutions, which cannot bear the light of civilization, they could not be induced to remain in their isolated and desert home.

We learn from the report of Captain Beckwith, United States army, how very circumscribed is the area of land which is now susceptible of cultivation in the Desert, and the fact that families sometimes go a great distance from the settlements for the advantage of obtaining a few acres of ground susceptible of cultivation. (See page 65, vol. I, Pacific Railroad Report.) When the truth comes to be admitted, I think it will be found that the upper valley of the Rio Bravo, embracing New Mexico and a small portion of western Texas, is the only tract of land, within the limits mentioned in the preceding paragraph, where a body of land is to be found susceptible of sustaining any considerable population. And yet we see, since our occupation of that Territory, in 1846, the population has increased but little, if at all.

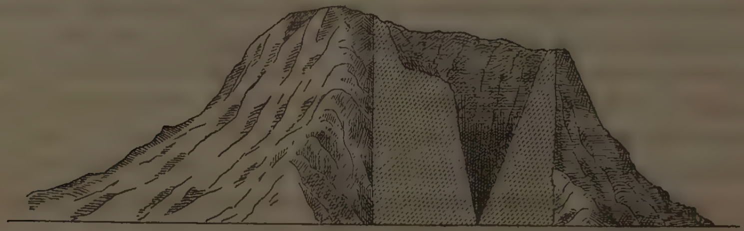
[EXTRACT FROM REPORT OF ASSISTANT ARTHUR SCHOTT.]

TERTIARY SHORE OF THE DESERT.

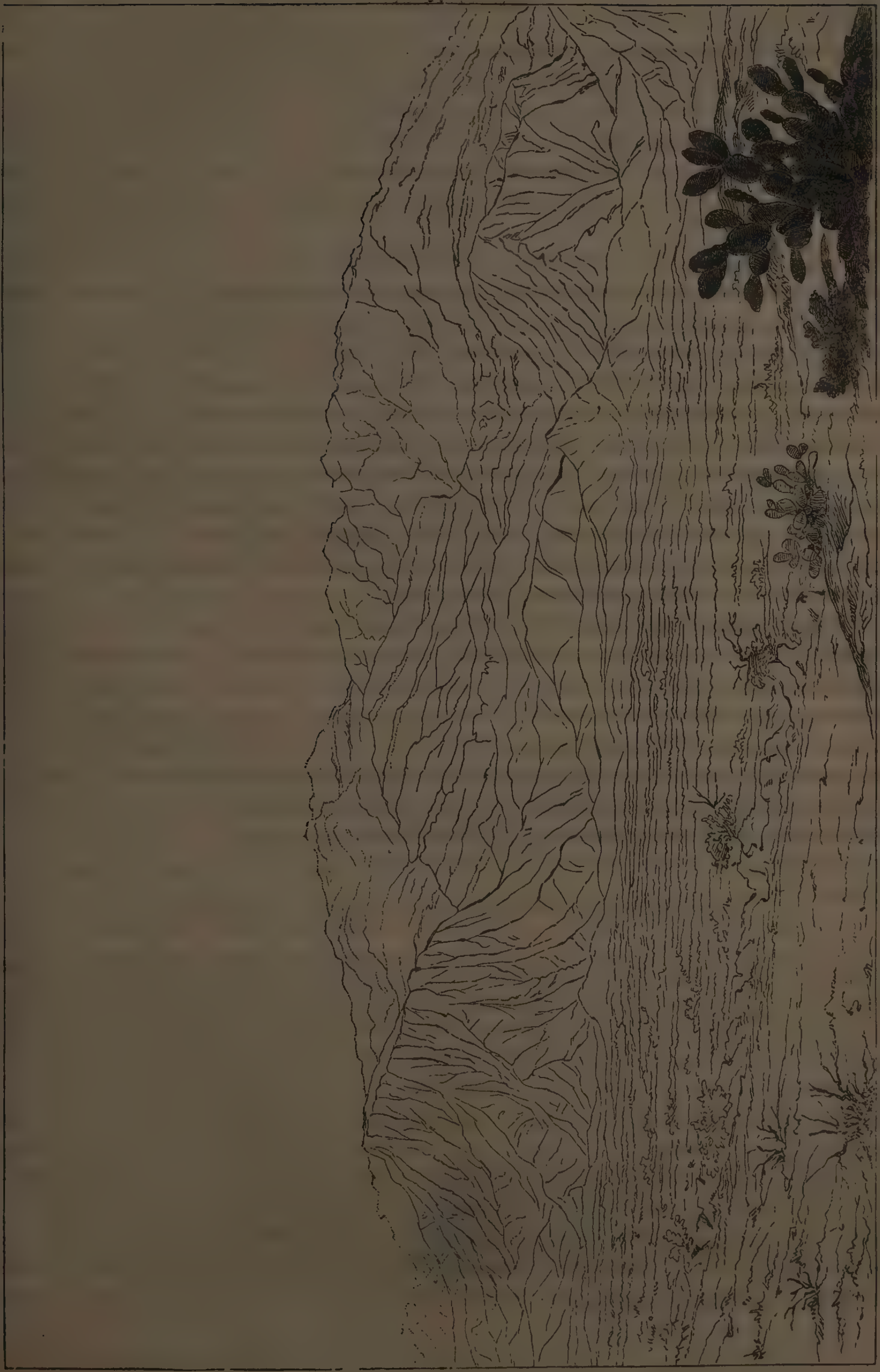
Vallecito, another small Indian settlement in a valley with a number of brackish springs, and abounding in saline soil, is situated on the upper edge of the Desert shore. From Vallecito the road continues along the dry bed of a mountain torrent, deeply filled in with shifting sand. This sand stream seems to form one of the heads of Carrizo Creek, and winds through dreary flats, flanked on both sides by the naked, desolate slopes of the primary and metamorphic mountains. The latter finally cease, and Tertiary ridges, supported by dark masses of eruptive rocks, take their place. These form the real edge of the Desert ocean, which, no doubt, was once the bottom of a wide salt-water basin. The washing of tidal oscillations upon this bold shore caused, probably, the dune-like deposition of the Tertiary hills along the foot of the western Cordilleras. To confirm this supposition of their origin, an isolated group of seabeach-loving palms appear to the left of the road, near Carrizo Creek, marking, at the same time, a spot with permanent water. A brief but graphic description of those Tertiary ridges and hillocks has been brought before the public in Major Emory's report of 1848.—(See page 103.) A sketch of these hills is herewith given.

VOLCANIC VENTS.

Among the Tertiary ridges and hillocks, one may be recognized at once by its singular shape, appearing to be the vent of some volcanic activity now silenced. Major Emory, according to our knowledge, set forth, prior to any other writer, the supposition of the true nature of these hills. After close examination we are able to corroborate the correctness of that supposition. Another not less convincing proof of its neptuno-volcanic origin may be sought in its geographical position, which is upon that long volcanic seam, running north and south, and lining the eastern base of the Peninsular Cordilleras, parts of which are still in activity.



VERTICAL SECTION OF AN EXTINCT CRATER IN THE TERTIARY FORMATION, BORDERING THE EAST SLOPE OF THE CALIFORNIAN CORDILLERAS.



VIEW UPON THE EASTERN SLOPE OF THE CALIFORNIAN CORDILLERAS FROM NEAR CARRIZO CREEK.

SOLFATARAS.

Some volcanic mud springs or solfataras, to the north, in the Colorado Desert, have been visited by Dr. J. Le Conte, of Philadelphia, in company with Major Heintzelman, U. S. A., then commanding officer at Fort Yuma. The former gives an interesting account of his visit there in Silliman's Journal, vol. xix, second series, No. 55, January, 1855. The existence of these springs, however, was not altogether a new discovery of this party, but was well known before to the natives of the country, who resorted to this locality for their annual supply of salt.

The other springs, southeast from Carrizo Creek, and not more than twenty miles from the lower Colorado, were visited also, in 1853, by the same officer, accompanied by a small party. The time this officer had chosen for his trip was about three months after a severe shock of an earthquake, which had terrified the inhabitants of those regions on the 29th November, 1852.

We are indebted to the liberal kindness of Major J. H. Thomas, the successor of Major Heintzelman, in command of Fort Yuma, for a glance at the manuscripts of the latter. The description of the springs and what was known is, in substance, as follows: "There exists, about forty-five miles below Fort Yuma, in the Desert between the western Cordilleras and the Colorado, a pond, considered as an old orifice, which had been closed for several years." "The first shock of an earthquake, in 1852, caused there a mighty explosion. The steam rose a beautiful snowy jet more than 1,000 high into the air, where it spread high above the mountains, gradually disappearing as a white cloud.

"This phenomenon repeated itself several times in a diminishing scale. Three months later I visited the place; jets took place at irregular intervals, from fifteen to twenty minutes. The effect was beautiful, as they rose mingled with the black mud of the pond. The temperature of the water in the principal pond was 118° Fahr., in the smaller one 135° Fahr., and in one of the mud holes, from which gases escaped, 170° Fahr. The air which escaped was full of sulphurated hydrogen, and in the crevices crystals of yellow sulphur were found. The ground near about was covered with a white efflorescence, tinged with red and yellow. On the edge of a small pond crystals of sal ammonia, 1 to 5 inches long, were collected."

CLAVIJERO'S ACCOUNTS OF LOWER CALIFORNIA.

Other important data bearing upon the geology of Lower California have been brought before the public a long time ago by Clavijero, one of the missionaries in the southern part of the peninsula. He mentions, in his Historia de la Antigua ó baja California, (see Book I, Chapter II,) "two lagoons near the mouth of the Colorado; the red water of the former gave rise to the river's name." The water is described as being very caustic, and so bad that it causes instant swelling and ulcers, accompanied by a burning pain on any part of the body that is brought in contact with it. The effect is said to last for several days. The cause of these bad qualities is likely to be a certain bituminous mineral issuing from the bottom of those lagoons, where some navigators noticed it first in weighing their anchors.

Besides these lagoons quite a number of interesting facts are mentioned by the same author.—(See Book I, Chapter III, of his work.) Relating to the volcanic character of the shore skirting the base of the Peninsular Cordilleras, the volcano of Mulegé, near 27°, is mentioned. It was

discovered in 1746, by the missionaries; but the Spaniards living there made no mention of any eruption or earthquake caused by it. Native sulphur and pummice abound on the slopes and in the vicinity of this mount. A volcanic axis seems to traverse the peninsula from shore to shore, that is, from the mouth of Mulegé River to the Ballena's Bay, where, besides native sulphur, much vitriol occurs.

At a place called Kadakaamang, near the Mission of San Ignacio, in latitude 29°, an argillaceous mount is mentioned near the beach. On its slope, about 200 feet above the level of the Gulf, there is a horizontal stratum of fossil shells two feet thick.

About seven miles distant from this place a great many fossil oysters are found, some of them being of extraordinary size. One of the missionaries collected some measuring 1 foot 5 inches long, 9 inches broad, and 4 inches thick, and weighing 23 Spanish pounds. It is worthy of notice that here, and in other parts of California, from such fossil shells an excellent lime is prepared.

Around the Bay of Mulegé fossil ostrea are recorded to be quite common, especially on a high mountain in the vicinity of the beach. The rocks here are described as exceedingly hard, and well adapted to building purposes. It abounds in fossil shells, which are found imbedded in the innermost strata. It contains also numerous cavities, which seem to have been once occupied by some marine animals now extinct. This certainly proves a submarine formation of the mountain.

Rocks of a similar class occur frequently along the whole coast of the Gulf. Seven or eight miles from Loreto, in a locality surrounded by high mountains, is a ridge which is said to consist entirely of layers of fossil shells; similar localities are known to exist more than twenty miles from the Pacific coast, near the Mission of San Luis, on the north side of the Sebastian Viscaino bay.

Clavijero thus concludes: "Considering these facts in connexion with the various traces of volcanic activity, and the lar number of islands surrounding the Peninsula, we may imagine what revolutions nature has performed upon this ground. It is, moreover, beyond doubt that the sea has subsided (decrecido) in many places along the coast."

The missionaries of Loreto observed there, during less than forty years, that the tide marks of the sea had receded many yards from the coast, and also that such receding was more perceptible on the west coast. The whole space between the beach and the mountains, a distance of about 26 miles, is deeply overlaid with coast sand (arena litoral.) It is, therefore, evident that the Peninsula in its present configuration has more width now than before our historical era. We may also surely suggest the probability of a continued expansion of the land, until that multitude of islands around California shall be connected with each other and be consolidated finally with the main land.

VOLCANISM THROUGH THE GULF BASIN.

North of Carrizo Creek the country between the Gulf Basin and the Pacific exhibits perfect congruity of petrographic features. There is, for instance, the Pass San Gorgoño y Bernardino, formed by two huge mountain masses, with an elevation of from 7,000 to 8,000 feet each. Here diluvial deposits form a natural bridge of about two miles in width through that mighty

granite gate. This was once the passage of the tidal currents between the Atlantic and the Pacific.

The protrusion of eruptive masses skirting the base of the California Cordilleras seem to have been checked here by some means; their occurrence is at least less frequent in this neighborhood. A little further north, however, another shoot of igneous and metamorphic rocks abuts against the western granite walls. They are a northwestern continuation of the Sonorian Gulf Sierras, crossing the Colorado Valley in the vicinity of the mouth of the Gila, and joining the California Cordilleras somewhat to the north of the before mentioned mountain pass.

Along the eastern base of the Sierra Nevada we find volcanic activity again fully developed. It not only skirts these walls of primary and metamorphic rocks, but seems to have its theatre over the whole area between the Rocky Mountains and the Sierra Nevada.

According to the accounts of American and other explorers, this vast area abounds in salt lagoons, soda lakes, solfataras, geysers, warm and hot springs of various character, extinct craters, and other traces of wide-spread volcanoism.

Tertiary deposits seem not to be wanting throughout these regions; some of them are proved beyond doubt to belong to the Miocene age. Numerous fossils, verifying such conclusions, have been collected by various persons connected with government expeditions. Among other discoveries, is one of the highest importance; this is, the existence of a fossil shell (Cardita planicosta) on the Pacific slope of the Sierra Nevada. This shell, originally belonging to the Paris basin, is common also on the Atlantic side of this continent, and is now known to occur also on the Pacific. From this we have the proof of a former immediate connexion in these latitudes between the two oceans of our globe.

Without making any further mention of other numerous geological and palæontological facts relating to those regions which have been brought to light since the last decenium, we consider the area from the present head of the Gulf up to the Great Salt Lake basin as one tertiary, if not quaternary sea. There were, besides the present Gulf, other inlets from the Pacific to this interior sea; some of them we know already, and others, no doubt, will be discovered a short time hence.

However wide this inland sea may have extended, we find on its western shore primary and metamorphic rocks lined by tertiary strata, and on the east shore metamorphic and volcanic rocks prevail.

The bottom of this present waste, thickly overlaid with diluvial deposits, seems to have been thrown out of its level by upheaving forces from below. We may call them pluto-volcanic, employing a term to designate the immediate ejective forces and the upheaving motions of a general character.

In the regions before us we have innnmerable traces of ejected masses, in the shape of igneous dykes and sierras of similar petrographic character, but varying in size. We find, in fact, the former horizotalism of the whole Gulf basin along the Rio Grande and its tributaries, everywhere traversed, intercepted and broken up by metamorphic and igneous mountain ranges. It seems that the observer, in no other locality, stands in closer presence of these very pluto-volcanic upheaving forces, than on the western edge of this ancient inland sea. Whoever passes over this ground, particularly the desolate scenery about Carrizo Creek, if his mind should be the least open to impressions of this kind, must be struck with awe! He will find himself in a locality where nature gives, in a few bold words, a whole sentence of her cosmogonic history.

Here we everywhere find distinct marks of metamorphism, the result of a closely allied cyclopean and neptunic activity.

Changes in the physiography of the country.—One fact closely connected with the physiography of these desert regions is worthy of notice. The regions around New River and other beds of drainage, are inhabited by Indians, who raise on those alluvials, pumpkins, melons, and reap the seed of certain grasses and seeds, especially of an "Amaranthus," called by the Mexicans "Quelite," and by the Americans "Careless weed." These plants are dependents of alluvial soil.

At present the New River is often subject to dry up entirely for one or two successive seasons, thus leaving this forlorn people to the most bitter adversity. Whether this was always the case we were not able to find out, but there is some probability such was not, for if it had been so, these Indians or their ancestors would not have settled in this neighborhood.

According to traditions and observations made on the spot, water must have been distributed in former times more abundantly over the desert west of the Colorado, since either changes in the conditions of the climate or alterations in the level of the land, or both, must have taken place, causing a gradual diminution of drainage, and necessarily a subsequent decrease of population.

All accounts which have come to our knowledge agree upon an increased sterility of soil. Several localities are pointed out where in former times plenty of grass and mezquite, besides spacious planting grounds, were found.

Pascual, the present chief of the Yuma Indians, when a child, lived at "Alamo Mocho," where at the time (he is now about 60 years of age) water was running constantly, as it did also at New River. The place of Pascual's childhood was called Hu-ta-pil, because plenty of tunas (the fruit of opuntia) grew there. Of all this, nothing seems to have been left but the name "Alamo Mocho," (stunted cotton-wood,) as one tree of the kind marked this locality long after water had ceased to run here. If such changes really have taken place, and there is hardly room for doubt, we are inclined to ascribe the cause to an alteration of level—hyetographical changes being, perhaps, but the result.

It is not improbable that this portion of the Peninsula participated in a similar rising as Clavijero mentioned in regard to the southern regions of this country.

We have already mentioned the earthquakes to which these regions, together with all California, are subjected. They may be considered as principally instrumental in producing those general changes upon the surface. Here every three or four years heavy vibrations of earthquakes are witnessed. Major Heintzelman thus writes of a severe shock experienced the 29th of November, 1852: "At the time the river was unusually low, and (the Laguna) behind the post uncommonly high. (Behind Camp Yuma there is an old river bed.) Low grounds became full of cracks, many of which spouted out sulphurous water, mud, and sand. Further below, the river bed was changed considerably. The re-opening of a salfatara in the southwest corner of the desert was mentioned as the result of this earthquake."

Similar accounts of the same event were given by another eye-witness. He was at the time on board a small river steamer, about twenty miles below the mouth of the Gila, and on guard, when a heavy shock was felt on board, upon which the general alarm was given, "Boat aground!" Our informant, formerly a sailor in the South Pacific, on the coast of Peru, and

also a visitor of the Sandwich Islands, having witnessed there the outbreak of the notorious "Ruaroa," knew instantly what it was, and coolly remarked, touching bottom with a sounding-pole: "Yes! Boat aground in eight feet water!" The waters of the river were thrown in a sort of boiling motion, with a strongly rippled surface. The river banks on one side caved in; and on the other separated in a thousand cracks, from which dust, sand, mud, and water was jetting. In front of the steamer, at the time, there was a ferry-boat, loaded with sheep, just crossing the river. The hands in charge of it not knowing what to think of the phenomenon, in their fright threw away their oars and poles, and held on to the sides of the boat, expecting to go down. The river formed new bends, leaving portions of its old bed so suddenly that thousands of fishes were left lying on the muddy bottom to infect in a few days the air along the river by their putrefaction. The frequency of earthquakes occurring here forms also a point in the mythology and traditional tales of the aborigines, which has been referred to elsewhere.

Mountain rupture.—Eight miles below Fort Yuma another trace of the action of earthquakes is exhibited on the eastern foot of the Sierra Culaya, or Pilot Knob, as it is styled by the Americans. The metamorphic rock forming the knob is a dark syenitic granite, with much hornblende. At its base the Colorado turns abruptly to the south. One of the outrunners of the sierra shows a rupture with an average width of about thirty feet. The edges of this mountain cleft fit each other, so as to leave no doubt that they formed one mass. By means of this gap the post-tertiary banks of the river, 70 feet high, can be seen. (See annexed sketch.) The course of the Colorado, which runs on higher ground than the surrounding desert, and the configuration of the junction of the Gila and Colorado, (elsewhere described,) is, perhaps, another result of a geological disturbance in the general level of country.

Dr. J. Leconte, in his notes on some volcanic springs in California, which have been heretofore referred to, mentions also the anomalous course of the Colorado not taking the lowest level of the desert, but retaining its bed about 130 feet above it. He ascribes the cause to the deposition of its sediment, somewhat like the Mississippi and other rivers in our southern States.

The explanation ascribing the anomalous course of the river to the deposition of its sediment may be correct to some extent, but we deem it not sufficient to account for so great a difference of level.

A glance at the profile of this country will explain the relation between its geological and meteorological condition, which I have before hinted at.

Clouds rising from the ocean, borne by aerial currents towards the mountain slope of western California, ascend easily towards the dividing crest. As soon, however, as they pass that line they meet columnar currents of heated air whirling up from the intensely insulated desert flats; dispersion and dissolution of those aqueous deposits of the atmosphere follow naturally, and hence the almost incessant drought the Colorado basin is subject to.

Rain destined to fall upon these desert regions needs probably some heavier disturbances in the electro-magnetic action of the air, and hence what is called the rainy season in these regions is nothing more than the hottest time of the year, when electro-magnetism comes to its highest pitch of activity.

Equal causes produce similar results, therefore the meteorology of the Colorado basin and Northwestern Sonora are nearly related.

VALLEY OF THE COLORADO DEL OESTE AND EAST SLOPE OF THE SIERRA, CULAYA.

UNITED STATES AND MEXICAN

BOUNDARY SURVEY,

UNDER THE ORDERS OF

LIEUT. COL. W. H. EMORY,

MAJOR FIRST CAVALRY, AND UNITED STATES COMMISSIONER.

GEOLOGY AND PALÆONTOLOGY

OF THE BOUNDARY:

BY

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GEOLOGY AND PALÆONTOLOGY.

Colonel W. H. Emory,

Commissioner for the United States and Mexican Boundary Survey.

Sir: In accordance with your direction, I herewith transmit to you my report relating to the Geology and Palæontology of the Boundary Survey.

The collections of the original survey were placed in my hands, in 1853, by Dr. C. C. Parry, of the Boundary Commission. These consisted of a series of rocks, minerals, and fossils, collected along the line of the survey, and along the route travelled through Texas. The fossils consisted chiefly of Cretaceous and Tertiary species; and some of these had previously been submitted to Mr. Conrad, who described several species in the Proceedings of the Academy of Natural Sciences, of Philadelphia. There were still in the collection a considerable number of undescribed species; and although placed in my hands for final arrangement and disposition, I preferred that Mr. Conrad should complete the work he had begun, and accordingly transferred the new species to him for description. In the meantime, I had the drawings made and arranged as far as practicable previous to May, 1854. At this time an examination of some collections that had remained in Washington brought to light other species, and the number of figures and plates were increased by these additions.

The collections of the Survey of the New Boundary, in 1854 and 1855, have also contributed several new species to those previously described, and these I have likewise submitted to Mr. Conrad,* in order that the descriptions might, as far as practicable, possess a unity of character and design.

The collections have largely contributed to our knowledge of the extent and character of the Cretaceous formation in the southwest. This information, taken in connexion with the results which have been obtained in the west and northwest, enable us to determine with a great degree of accuracy the character and relations of the different members of the Cretaceous period, as developed in the United States.

The collections of Palæozoic fossils contain specimens from the upper carboniferous or coal measure limestone, which is known to become extensively developed in the west and southwest. A single specimen of *Asaphus* (*Isotelus*) indicates the existence of lower silurian strata, and since the specimen is scarcely worn, it cannot have been transported from a distance. It is the first specimen of undoubted lower silurian age that has fallen under my observation in all the collections that have been made in the southwest. I should not, however, omit to remark, that a specimen of coral found in the same locality (though exhibiting no decided marks of trans-

* Except the few species of Echinoderms, which, at the request of Mr. Conrad, I have described in their proper place, one only being a new species.

portation) is apparently identical with specimens found in the immense drift deposits far to the northward, in Nebraska and at other places; and although quite possible that both the trilobite and the coral have been derived from the extreme northern exposures of the older rocks, I am nevertheless prepared to expect that these formations will be found nearly coextensive with the carboniferous limestones.

Although there are among the collections of the Boundary Survey several specimens which appear referable to a position below the carboniferous limestones, and in the later collections some silurian or devonian corals, yet in the absence of other information than that furnished by the specimens, which do not bear evidence of having been freshly broken from the rocks, I do not feel warranted in drawing any general conclusions. This subject is one of the greatest interest for future explorers in that region.

The specimens of igneous and metamorphic rocks from the eastern and central portions of the route travelled are all unlike those so well known in the eastern part of the United States; and it is not until we approach the range of the Cordilleras that we find specimens bearing all the lithological characters and associations of the metamorphic rocks of the Appalachian chain.

We are constrained to believe, not only from the evidences of this collection, but from others previously examined, that the metamorphic rocks of this intermediate region are to a great extent newer than those of Silurian and Devonian age, which we know to be the age of a large part of the metamorphic portions of the Appalachian chain. This conclusion, or we may say suggestion, is deduced from the differences in lithological character, as well as from the fact, already stated, that the upper carboniferous limestone is the most conspicuous unaltered rock of the region, while in some places this rock itself, as well as strata of more recent date, appear to pass into a metamorphic condition.

In regard to this carboniferous limestone, it should also be borne in mind that it is not the carboniferous limestone of the Mississippi valley which attains this force farther west, but a limestone high in the coal series, and which has become thus developed, while we are yet ignorant of the existence of the lower carboniferous limestone in that part of the country.

The collections of the Boundary Survey, when compared with those made in traversing the country along lines farther to the northward, present a great similarity of aspect and lithological character. The cretaceous belt, bordering the metamorphic and igneous region which succeeds in turn, and in the midst of which are large areas of limestone just mentioned, and also some smaller areas of cretaceous rocks, which have now been traced quite to the central part of the great basin to the west of the first mountain chain, and have more recently been determined in California.

We have the means of knowing, therefore, the general geological structure of the country, from near the northern limits of the United States to Mexico.

The first part of my report, constituting the observations upon the specimens collected, and the general results regarding the geographical distribution of the formations along the line of the Boundary Survey, are essentially the same that I transmitted to you in 1854; but which, in consequence of the change in the boundary line making a re-survey necessary, were not published at that time.

I have since reviewed the whole collection, with all the additional information derived from

other sources, and comparison of other collections from rocks of the same age, and particularly those of the cretaceous period from western localities and from New Jersey. These results are given in the chapter upon the relative position of the cretaceous fossils of the Boundary Survey with other known cretaceous formations in the United States.

The relations of the carboniferous limestone of the Rocky Mountain range, I have endeavored to make more clear by a few pages upon the carboniferous rocks, and a section of the principal members belonging to that period, as known in the Mississippi valley.

The specimens from the Tertiary formation of the southwest, although indicating a general similarity to the formations of Nebraska, are nevertheless insufficient to give the means of careful comparison and reliable conclusions.

Our knowledge of the geological formations of the west is now so rapidly progressing, and the materials accumulating in such abundance, that whatever may be presented to-day as new and in advance of previous knowledge, will to-morrow be regarded only as a historical record of our progress. The facts here presented, and the conclusions deduced from these and other collections which I have heretofore examined, may serve as a contribution towards a more perfect elucidation of the geology of this great central region, which has been traversed by the Boundary Survey commission.

I have the honor to remain, very respectfully, your obedient servant,

JAMES HALL,

OBSERVATIONS UPON THE CHARACTER AND GEOLOGICAL AGE OF THE SPECIMENS OF ROCKS AND MINERALS SUBMITTED TO MY EXAMINATION FROM THE COLLECTIONS OF THE UNITED STATES AND MEXICAN BOUNDARY SURVEY.

I. *Specimens from the Gulf Coast, Texas, as far as El Paso, including all those from the east side of the Rio Grande.*

1. Calcareous sandstone, branch of the Guadaloupe river below San Antonio. This rock is apparently of Tertiary age, and presents nothing peculiar in its character, except its loose aggregation and numerous dark siliceous specks or grains.

2. Calcareous conglomerate, fifteen feet thick.

These specimens bear the character of the Tertiary sandstones known in Kansas and Nebraska. They are sometimes highly calcareous. The sandstone varies in character from loosely aggregated and incoherent sand to a compact calcareous sandstone or quartz rock, for the grains sometimes appear to have been cemented by fluid silica.

From information obtained in connexion with these specimens, the strata to which they pertain occur in outliers of greater or less extent, the original formation having been subjected to extensive denudation. The similarity in lithological character and association suggests a probable identity in age between these beds and those of the Mauvaises Terres of Nebraska; and that the Tertiary is probably co-extensive with the cretaceous formation from Nebraska to Texas and New Mexico.

3 and 4. Argillaceous, buff-colored limestone, a thickness of fifty feet, ascertained in sinking a well, while the entire thickness of the rock is much greater. This rock is used for buildings in San Antonio. It has the same lithological character as the stratum which elsewhere contains *Inoceramus mytiloides.—I. problematicus.*

5. A yellow granular limestone of similar character, but more compact than the limestone of Timber creek, New Jersey. The specimen contains a species of cardium. The rock from which this specimen was obtained occurs about twenty miles further to the west than Nos. 3 and 4, and is penetrated in reaching a more compact stratum below.

These specimens are from the lower part of the cretaceous formation.

a. *Specimens from the table-land on Devil's river.*

6. Light gray limestone with cretaceous fossils. Painted caves.

7. A more granular limestone than the preceding, resembling No. 5 in character, and containing valves of an *Ostrea.* Painted caves.

8. Compact, reddish brown granular limestone, containing *Nodosaria.* This rock, on its weathered surface, is of the character of the preceding, but more compact and crystalline in its texture.

9. Compact, subcrystalline, yellowish limestone; sometimes of a brownish yellow. Table-land beyond Devil's river.

10. Vesicular trap from isolated hills and ridges rising from the table-land.

11. Compact, light ash-colored limestone, containing cretaceous fossils; among which are *Lima Wacoensis*, *Trigonia Emoryi*, *Gryphæa Pitcheri*, and other species. Camanche crossing, Camanche springs.

b. *Specimens from the Limpia range of mountains, between the Pecus river and Rio Grande.*

12. Brown porphyritic trap rock, with crystals of Adularia.

13. Coarsely crystalline igneous rock, (trap-like in some parts,) composed in a great proportion of crystallized feldspar or Adularia, having a châtoyant lustre on the cleavage faces. This rock forms the central part of the mountain range.

14 Compact quartz rock, of a slightly reddish tint, with minute cavities.

15. Compact white opaque quartz, approaching chalcedony in its characters.

These specimens from the Limpia range are of igneous origin, the quartz rock having been derived doubtless from the gelatinous silica produced by volcanic waters. We have no evidence from the facts before us that any part of the range consists of Metamorphic stratified rocks. They are mostly of reddish-brown porphyry and a coarse granitic aggregate, of which Adularia forms a large part. Some specimens of milky quartz appear as if due to depositions from hot springs.

c. *Stratified rocks to the northwest of the Limpia range.*

16. Compact, fine grained limestone, dipping to the southwest.

17. Same as the preceding.

18. Limestone of similar character to the preceding, containing remains of crinoidal columns and shells.

19. Similar limestone with remains of shells; (Brachiopoda, etc.)

20. Limestone like the preceding, of a grayish blue color, containing fragments of *Terebratula*, etc., (probably *Terebratula subtilita.*)

Although these specimens present no well marked fossil species, I am nevertheless quite convinced, from the character of the fragments preserved, that the rock is of the age of the upper carboniferous limestone. The condition and character of the rock with the fragmentary fossils is precisely identical with specimens from the neighborhood of the Great Salt lake and other western localities. They contain remains of small Terebratula in like manner; and the numerous fragments of organic bodies which cover the weathered surfaces indicate sufficiently that the rock is in great measure composed of similar materials. Some of the specimens are quite compact, and others are granular in texture; they are traversed by minute veins, sometimes of calcareous spar, and sometimes of harder material.

21. Siliceous tufa, resembling trap tuff. It consists of an aggregation of finely divided siliceous matter, porous or minutely cellular in structure. It is represented as forming dykes in the limestone. Two specimens from Eagle spring.

22. Specimens similar to the last, but coarsely laminated, and with minute concretions; brecciated, etc. Eagle spring.

23. Light-colored amygdaloid rock. Eagle spring.

24. Porphyritic trap. Eagle spring.

25. Brown porphyry; compact.

26. Brown porphyry; same as the preceding, except that it contains cavities, which are probably due to the weathering out, or solution of crystals from the mass.

27. Chalcedony mixed with Feldspathic lava. This rock has been formed by gelatinous silica penetrating scoria or other loose volcanic materials.

28. Chalcedony. Two specimens, associated with the preceding rocks.

The volcanic products present numerous modified conditions, from the effect produced by silica in solution, or in the gelatinous condition, having penetrated the mass. From this cause, and from the effects of heated water, not only the lithological aspect, but the color of the rock is often greatly modified.

29. A siliceous stratified rock, apparently a highly altered sandstone. From the Rio Grande, seventy miles below El Paso.

30. A porphyritic trap-like rock, perhaps a sedimentary rock altered by volcanic action. Seventy miles below El Paso.

31. Greenstone trap. Seventy miles below El Paso.

32. Volcanic breccia, a gray feldspathic mass with hornblende. Same locality as the last.

33. Volcanic breccia, becoming porphyritic; more compact and crystalline than the preceding.

34. Granitic mass; a volcanic granite, composed of feldspar and hornblende, with little quartz; probably a further modification of the breccia by igneous action. Seventy miles below El Paso.

The range east of the Rio Grande, seventy miles below El Paso, has furnished specimens of reddish and greenish compact porphyry, compact trap, a specimen of granitic structure consisting of feldspar, mica, and some earthy matter, but loosely aggregated, not unlike the products of recent igneous formations; also several specimens of volcanic breccia loosely aggregated, and a single specimen of similar composition very compact in texture. From this locality there is also a specimen of carboniferous limestone, partially crystalline, and one side permeated by innumerable minute pores; but it still preserves evidences of organic remains on its weathered surfaces.

d. *Specimens from the Tertiary Basin of the Rio Grande.*

35. Selenite mixed with marl from a bluff composed of marl, gravel, and beds of selenite. The crystals occur in detached groups, but altogether form large beds.

36. Cretaceous limestone with *Exogyra texana*, and *Serpula*. El Paso.

37. Argillaceous limestone with *Inoceramus*, from the Rio Grande above El Paso.

38. Hornstone with seams, or a brecciated intermixture of limestone with hornstone, forming the summit of a mountain 1,200 feet high. The base of the mountain is composed of the upper carboniferous limestone. Near Frontera.

39. Black hornstone, surrounded by a lighter colored mass of the same. Near Frontera.

40. Feldspathic or granitic volcanic rock, composed mainly of Feldspar and Olivine. Two specimens from near Frontera.

41. Compact feldspar with a little glassy quartz: forming knobs and dykes running through the limestone strata; sometimes overlying and sometimes underlaying the latter rock. It is evidently of volcanic origin.

No. 40 forms isolated knobs less intimately connected with the limestone than No. 41.

The specimen marked "Isolated knobs near Frontera," consists of feldspar and olivine, and is a modern igneous product.

The specimen marked "Granite, north of Frontera," is a similar aggregate, more compact and containing scales of mica.

The mountain northeast of Frontera is partially composed of reddish feldspar with small grains of crystalline quartz; a kind of porphyritic rock. The position of this rock is remarkable and highly interesting. A sectional sketch of the mountain by Dr. C. C. Parry, represents it as resting on the upturned edges of the strata of carboniferous limestone, which form the base and greater portion of the mountain, and dip at an angle of 45°. The granitic aggregate rests on the sloping sides of the mountain, in the direction of the dip. At a little distance from this point, and apparently resting on the latter rock, occur cretaceous strata, highly inclined, as if the igneous mass had been forced out near the junction of the carboniferous and cretaceous beds. In other instances the igneous beds rest on the cretaceous deposits; leaving no doubt that the eruption took place subsequent to the cretaceous period.

The specimens from 35 to 41 inclusive, present the characters of the different members of a section across the Tertiary and cretaceous strata, to the upper carboniferous limestone; with the associated igneous rocks which form separate and isolated masses, or are more or less entangled in the stratified limestone.

e. *Specimens from the Organ Mountain range, fifty miles north of the locality of Nos.* 40 *and* 41. *The elevation of this range is about* 2,000 *feet above the bed of the river.*

The specimens from the Organ Mountains consist of compact feldspathic granite with very little quartz, a few scales of green mica and hornblende, and numerous minute crystals of magnetic oxide of iron. Notwithstanding the compactness of this mass, the character and mode of aggregation are so similar to some of the well-characterized volcanic products that it can scarcely be regarded as an ancient granite. Resting on this rock occurs very compact greenstone porphyry. A specimen from the western base of the mountain is a reddish lava-like porphyry with a finely porous or vesicular structure.

42. Granitic rock, composed of crystalline feldspar with a smaller proportion of quartz and hornblende. The specimen is less lava-like than No. 40, but it has the aspect of a very modern igneous rock. This constitutes the central portion of the mountain range.

43. Porphyritic greenstone, very compact, forming the mass partially surrounding No. 42. This rock occurs in distinct layers dipping at an angle of 82° W.

44. Brown porphyritic trap, overlying the granitic central mass of the mountain.

45. Reddish brown, compact, lava-like rock, containing minute crystals of feldspar; associated with Nos. 42, 43, 44, forming extensive masses.

46. Sulphuret and phosphate of lead, sulphuret of copper, and sulphate of baryta. There are several specimens all presenting the same general character, and obtained from a vein in the mountain range.

47. A coarse porphyry; a red, coarse, loosely aggregated base. Near the San Antonio road.

48. Volcanic breccia. Near the San Antonio road.

49. Amygdaloidal trap; a common, grayish base with round vesicles. Tascate.

50. Porphyry.

51. A porphyritic rock with chalcedony.

52. Compact, laminated porphyritic rock.

53. Compact, micaceous, gneissoid sandstone, slightly calcareous; dip S.S.E. 60°.

This sandstone has the aspect of a cretaceous or tertiary sandstone.

54. Laminated, compact, argillo-calcareous rock, which has been subject to igneous action, and partially altered.

The two preceding specimens are from strata overlaid by trappean rock, before noticed; and their altered condition is doubtless due to this action. This fact places the date of these eruptions subsequent to the cretaceous period, and perhaps posterior to the older Tertiary deposits.

55. Encrinital, subcrystalline, light-gray limestone, containing numerous fossil fragments; belongs to the upper carboniferous period; dip to the southeast. Cibolo creek.

56. Argillaceous sandstone with mica, fine-grained and thinly laminated. The age of this sandstone is doubtful, but it may be carboniferous. Cibolo spring.

57. Compact porphyry. Cibolo creek.

58. Limestone of the upper carboniferous period, forming high mountains; dip southeast. Presidio del Norte.

This rock is similar to that from Cibolo creek, but more compact and less crystalline, and evidently has undergone a partial metamorphism.

A specimen from the rapids of the Del Norte is of a bluish ashen color, very compact and fine-grained, with numerous crystalline points and lines which mark the presence of organic bodies. Although no fossils can be recognized in their specific character, yet the rock is so precisely of the character of the carboniferous limestone in numerous western localities as to leave no doubt of its true age and geological position.

The specimens from Buffa-silla, marked "Aug. 10," consist of the following: two specimens of vesicular lava, one of compact breccia, enclosing fragments of lava, and several specimens of trap tuff, enclosing quartz pebbles and fragments, and becoming, in one specimen, a sort of friable breccia. Another specimen from the same locality, marked "Aug. 13," is a compact, volcanic breccia, composed mainly of fragments of various volcanic materials.

59. Vesicular lava, Buffa-silla.

A second similar specimen.

60. Compact lava, Buffa-silla.

61. Volcanic breccia, composed of fine white volcanic ashes, with pebbles and fragments.

62. Coarser breccia, with a coarser base than the preceding.

The compact lavas are represented as lying below, and the breccias between these and the more cellular lavas above. Sometimes there are several successive series of these beds.

63. Granitic or compact feldspathic lavas, with quartz and hornblende in small proportions. Three specimens from the cañon of the Rio Grande.

A specimen from the cañon of the Rio Grande, marked "Aug. 27," consists of a crystalline aggregation of quartz, feldspar, and carbonate of lime. Two other specimens, same date, from Puerto Peak, are granitic aggregations of quartz and feldspar, and appear much like a partially fused breccia.

64. Cemented volcanic ashes, with, occasionally, small vesicles, giving an amygdaloidal character.

Three specimens, showing variety (of 64.)

65. Breccia with a white base.

66. Lava, less compact than that below.

The series shows the succession of compact lava, breccia, and less compact, or vesicular lava above.

67. A fragment including part of a cavity in amygdaloid, with green quartz.

68. Brownish porphyritic rock. This has the common character of the porphyry of the region.

69. Crystallized peroxide of iron, connected with the trap or lava deposits.

70. Porphyritic granite, apparently of very modern origin.

71. Sienite or porphyritic granite, varying but little from No. 70. It contains dark smoky quartz.

72. Reddish porphyry or porphyritic trap, associated with the preceding specimens.

73. Compact argillaceous limestone of the Cretaceous formation.

74. Compact, close, and fine-grained argillaceous limestone of the Cretaceous formation.

75. *Exogyra texana*, from above the Pecos river.

76. Argillaceous limestone, with *Exogyra*, containing cavities filled with calcareous spar.

77. Fossil wood from Tertiary strata; Eagle Pass.

II. *Specimens from the country west of the Rio Grande.*

78. Sandstone, compact and fine grained. Cemialauke.

This rock is said to form a mountain range in connexion with the conglomerates. The specimens are not sufficient to determine satisfactorily the geological age of the formation.

79. Carboniferous limestone with fossil remains.

These specimens, (79,) from west of Salado, have evidently undergone partial metamorphism, though still preserving fragments of organic remains. One of them contains several imperfect shells, among which a Terebratula is distinguishable.

80. Porphyritic lava, connected with the preceding limestone; and breccia, connected with the same.

81. Compact trap, with a silicious incrustation covering the surface.

82. Amygdaloid.

An extensive district is represented as covered by rocks like 81 and 82, on the southwest of Frontera.

83. Amygdaloid, similar to the preceding; one hundred miles west of El Paso.

84. Specular iron ore. It occurs in loose masses, scattered over the Tertiary plains.

85. Chalcedony, associated with trap rocks.

86. Feldspathic lava, or compact trap tuff.

Rocks of this character are represented as forming the dividing ridge and summit of the Sierra Madre near the Gaudaloupe Pass.

88. Quartz rock; some portions are granular, showing the passage from an arenaceous mass to a compact homogenous quartz rock.

(This is, apparently a metamorphic stratified rock.)

A specimen from the summit of the Gaudaloupe Pass presents the character of rounded

crystalline grains of quartz, in a paste of milky quartz. In many parts the granular structure is seen passing into the homogenous texture. This sandstone is associated with the carboniferous limestone.

89. A reddish colored stratified rock; apparently an altered shale becoming porphyritic.

90. An argillaceous sandstone; the granular structure gradually merging into a compact chalcedonic mass.

91. Conglomerate, associated with the preceding specimens, 89 and 90. The rock has the aspect of a Tertiary conglomerate.

92. A compact granular mass of feldspar and olivine.

93. A similar mass, colored by oxide of iron. The change of color perhaps due to infiltration of heated water.

94. Conglomerate, composed of quartz pebbles, trap, and other volcanic rocks, with much calcareous matter. The pebbles are somewhat angular. (A modern product.)

95. An earthy calcareous rock, associated with the preceding conglomerate.

96. Compact dark colored trap rock.

97. Talcous slate, with quartz veins.

98. Granite, fine, granular, consisting of quartz, feldspar, and mica, in nearly equal proportions, and having a more ancient aspect than the granite found associated with the trap rocks.

These two specimens (from the same locality) give the first indications of an approach to rocks of a character similar to those composing the Appalachian mountain chain; and which are like the products of metamorphic silurian strata.

III. *Specimens from the silver and lead-bearing rocks of the Corriletas.*

99. A compact silico-calcareous rock, with a few scales of mica. It appears to be an impure subcrystalline limestone, and is associated with other specimens of limestone. This is represented as forming the rock traversed by the veins of silver-lead ore.

100. Sulphuret of lead and silver.

101. Sulphuret and carbonate of lead.

102. Sulphuret of lead connected with a gray limestone.

103. Earthy carbonate of lead, said to contain silver.

104. Semi-crystalline limestone associated with the earthy carbonate of lead, which latter is represented as occurring in beds or veins, distinct from the sulphurets.

105. Limestone similar to the preceding, colored brown by oxide of iron.

106. Compact, silicious limestone, which has undergone some alteration from igneous action.

107. Compact, altered limestone, associated with the silver ores of the San Pedro mines.

A specimen said to be associated with the silver of the San Pedro mine is a greenish, impure limestone, with light colored or white crystalline points. The weathered surface presents minute cavities, and it has altogether the appearance of an ordinary greenstone. On testing by acids, it effervesces strongly, and is evidently highly calcareous.

108. Cretaceous limestone containing shells of Exogyra, &c., from the foot of the mountain in which the silver ores occur.

The cretaceous strata overlie the upper carboniferous limestones, and are shown to have been subjected to similar disturbances, so far as the elevation of the strata is due to such action.

109. Red oxide and green carbonate of copper.—Copper mines of New Mexico.

110. Green carbonate of copper.—Sonora.

111. Gray sulphuret and green carbonate of copper.—Copper mines of Presidio del Norte.

112. Sulphuret of lead and silver, with crystals of sulphate of lead.—Santa Rosa.

The specimens from Santa Rosa are from veins, and do not furnish any of the associated rock.

The specimens of rock from the Leon mine are a semi-crystalline limestone of a mixed gray and white color, with calcareous spar; and a crystalline limestone colored brown by oxide of iron. The other specimens from this locality are vein-stones or ores.

In the vicinity of the mines of Corriletas, the limestone has undergone still farther metamorphism, and some specimens which occur in the same connexion, and apparently of this age, assume a very crystalline character, and exhibit mica and some other minerals, which have been segregated from the mass during the progress of metamorphism.

The specimens of limestone from the Escandido mines include one of a yellowish white color and crystalline texture, containing disseminated crystals of iron pyrites: this may be a vein-stone. Another specimen is of very compact, bluish, granular limestone, with thin pressed veins of spar, evidently having undergone some metamorphic action. This is labelled as coming from the foot of the mountain adjoining the mines. Other specimens marked as from the same locality contain large numbers of fossil shells, but in such a condition as to afford very unsatisfactory means of determining their age. They present, however, many features like those of the cretaceous limestones, and are probably beds of that formation, which have undergone partial metamorphism.

B. SPECIMENS COLLECTED ON THE ROUTE FROM THE PACIFIC COAST EASTWARD, INCLUDING THE TERTIARY OF THE COAST AND THE METAMORPHIC ROCKS OF THE CORDILLERAS; THE TERTIARY OF THE GREAT PLAIN EAST OF THE CORDILLERAS, AND THE METAMORPHIC ROCKS OF THE ISOLATED MOUNTAINS IN THE GREAT PLAINS.

IV. *Specimens from the coast Tertiary belt, from the neighborhood of San Diego.*

1. Gray micaceous sandstone, with more or less of argillaceous matter, friable, or more or less compact.
2. Calcareous beds with shells, Turritella, Pectunculus, &c.
3. A fine chalk-like, tufaceous deposit, occurring in isolated beds.
4. Lignite, associated with clays and sands.

V. *Tertiary formations spreading over the plain east of the Cordilleras.*

1. Sands and marls with clays, all more or less calcareous; represented as forming extensive beds of considerable thickness, and cropping out in bluffs of several hundred feet high.
2. Shells of *Ostrea vespertina*, from the beds of the preceding series.
3. Calcareous tufa; forming isolated masses or deposits.
4. Gypsum—Selenite. This mineral occurs in the clays and marls of the formation.
5. Common salt, forming on the borders of lakes from evaporation. The soil is more or less permeated with saline matter, which is carried downwards to the depressions in which occur the small lakes having no outlets.

6. Sandstone. A fine-grained, friable, micaceous sandstone, occurring above the marls and clays, and represented as attaining a thickness of from 100 to 200 feet.

The sandstone contains nodules of clay, which are often large and flattened, forming an irregular or interrupted layer. These nodules are frequently surrounded by pebbles or small gravel. These pebbles consist of quartz, porphyry, greenstone, jasper, &c., and sometimes form layers of conglomerate. From the evidences of drift action afforded in the specimens, it is probable that the formation may at some points present extensive beds of conglomerate.

This sandstone is precisely of the same character as the Tertiary sandstone of the Mauvaises Terres of Nebraska.

7. Coarse sand and small pebbles cemented by calcareous matter, forming a conglomerate which has a thickness of 30 or 40 feet.

8. Fossil wood—an erratic mass found upon the plains.

9. Vesicular lava, having the cavities filled with earthy matter, and embracing small shells like Ceritheum, but too imperfect to be specifically identified.

The table-land occupied by this Tertiary formation forms the plateau in which the rivers take their rise.

V. *Specimens from the Coast Range.*

1. A somewhat vesicular trap or greenstone, containing spots and blotches of soft green earth.
1. Greenstone porphyry.

VI.—*Specimens from the westerly part of the Cordilleras.*

1. Chloritic rock, having a compact or scarcely laminated structure.
2. Chloritic or talco-chloritic rock, with hornblende, etc.
3. Black mica, with quartz veins.—Pine ridge, 16 miles E. of San Luis Rey.
4. White quartz, with schorl.
5. Quartz and feldspar; granitic in its structure, and containing schorl.—Near Santa Isabel.
6. Feldspathic granite, very similar to the preceding specimens.—Near Acapulco.

VII.—*Specimens from the central portion of the dividing range.*

1. Granitic or sienitic rock, composed of quartz with black hornblende in blotches and a little mica.—From the bare peaks of the Cordilleras, near the boundary line.

2 Feldspathic granite, somewhat gneissoid.

3. Feldspathic gneissoid granite.

4. Gneiss.

5. Hornblende rock; dark colored.

This rock is very similar in character to much of the rock of the Green mountain range.

6. Fine-grained syenitic rock, with hornblende in crystals on the surface.

The specimens enumerated above, from 2 to 6 inclusive, are evidently from the same formation of metamorphic rocks in the exposures of the different beds.

7. Rose quartz; from a loose mass, though probably derived from this metamorphic belt.

8. Black tourmaline; a loose mass.

9. Crystalline quartz, with black tourmaline.—Near the dividing ridge of the Cordilleras; east from San Diego.

10. Feldspathic granite, with mica in large plates. The locality south from No. 1 of this series, and belonging to the same (dividing) range.

VIII.—*Specimens from the eastern slope of the Cordilleras.*

1. Coarsely crystalline granite, with much mica and feldspar.—Lower California.
2. Similar to the last, but with a less proportion of feldspar.—Lower California, near the boundary line.
3. Talcose slate, with Anthophyllite.
4. Quartz in veins in the talcose slate.

IX.—*Specimens from the isolated mountains in the great plain of the Cordilleras, near the mouth of the Gila, on the west side of the Colorado River.*

1. Syenitic rock, composed of hornblende and feldspar.
2. Similar to the last, but finer grained.
3. A granitic mass, composed of quartz, feldspar, and mica, with black tourmalines.
4. A granitic mass, consisting chiefly of quartz with laminæ of white mica The quartz contains garnets.
5. Gneiss or mica slate, finely granular and laminated.
6. Epidote rock; crystalline.
7. Epidote with talc; (two specimens;) the talc in thin minute scales, and the epidote finely granular.
8. Epidote and talc; the epidote granular, but arranged in laminæ.

IX.—*Miscellaneous specimens not numbered.*

Specimens designated as follows:

"August 25," compact and amygdaloid traps.

"August 29," marked as the lower stratum, is amygdaloid, having the appearance of fine volcanic ashes, loosely cemented, and containing a few cavities filled with crystalline matter, and others empty.

"September 16," volcanic tuff.

"September 17," green quartz in a cavity of amygdaloid.

"September 30," specular iron ore connected with volcanic rocks.

"October 7," reddish, porphyritic lava.

"November 8, Mount Carmel," coarse syenitic aggregate.

"November 10," reddish vesicular porphyry.

"March 2, 1852," siliceous rock, apparently indurated trap tuff.

"March 26, 1852," granitic lava, or trap tuff, with crystals of feldspar, mica, &c.

"Summit of San Luis Mountains," an indurated tufaceous mass, with cavities lined with quartz.

"Mouth of Guadaloupe river," semi-metamorphic red shale.

"Conglomerate, mouth of Guadaloupe river," breccia, probably of volcanic origin.

"Santa Cruz Pass," compactly granular feldspathic rock, containing minute grains of magnetic oxide of iron. Another specimen is of vesicular trap tuff, colored red by oxide of iron.

"Rio Santa Cruz, above Tilbac," semi-indurated volcanic ash; also a specimen of coarse breccia.

"Igneous rocks west of Salado"—one specimen is compact, feldspathic lava; the other compact, coarse breccia.

"Laguna Santa Maria," finely vesicular trap, with siliceous incrustation.

"Twenty-five miles southwest of Frontera," highly vesicular trap or amygdaloid.

"Baranca," a granular amygdaloid.

The enumeration of this collection of specimens enables us to deduce some general conclusions of great interest regarding the geological structure of the country between the Gulf of Mexico and the Cordilleras range of mountains. The specimens from the eastern part of this range, taken in connexion with what we know of its character in other places, and of the geology between this range and the Pacific ocean, are sufficient to give a very correct idea of the intervening space.

A broad belt along the coast of the Gulf is occupied by deposits of very modern geological age, which may be referred to the same period as the drift and alluvium. This deposit consists of water-worn materials—as sand, gravel, pebbles, &c., which have been spread over the surface in a very regular and even manner. The general elevation of this belt is 300 feet above tide water, and varies little in its height for many miles in extent.

In several places the denudation of this deposit discloses beneath it formations of the earlier Tertiary period. Approaching the borders of the high table-land which commences at the head of navigation on the rivers, the cretaceous formation appears at numerous points in the river beds and banks, and elsewhere where the superficial accumulations are removed.

From the commencement of the table-lands westward, the specimens show the occurrence of a broad belt of the cretaceous formation, interrupted here and there by isolated dykes, or mounds of trap, or other igneous rocks of modern age. Basins of Eocene, marine Tertiary, likewise occur at intervals, resting upon the cretaceous beds. The specimens of the latter formation consist of limestones, some of them extremely compact and dark, and others light colored and friable. Various admixtures of these with more argillaceous matter, and greenish, calcareous sands, sometimes partially indurated, are of frequent occurrence. The numerous fossils collected from different localities leave no doubt in regard to the age of this formation.*

In localities where the igneous rocks are protruded through the beds of this age, a greater or less degree of metamorphism has taken place. Sometimes we find a partial or entire induration of the contiguous masses, and often their metamorphism is so great as to render it difficult to distinguish their age and relations from a simple examination of specimens.

Towards the west the igneous rocks, which first appear in small, isolated knolls, gradually

* I should not omit to notice in this place the very valuable and interesting work of Dr. F. Rœmer upon the fossils of the chalk formation in Texas, "*Kreidebildungen von Texas,*" &c. This gentleman passed more than two years in the United States, a considerable part of which was spent in Texas. Previous to the publication of this work he had published a description of that country, with a geological map, &c.

The collections now under consideration, though for the most part made at a distance from the principal localities cited by Dr. Rœmer, correspond to a great extent with those described by him, and corroborate in the most satisfactory manner his views of the general geological structure of the country.

assume more importance, and extend into long belts. In the Limpia range these rocks present the character of a mountain chain, having an elevation of 6,000 feet, and extending several hundred miles north and south. The specimens from this range present the characters of eruptive and metamorphic rocks. Notwithstanding the syenitic texture of some of the beds, they have still a modern aspect. The different minerals are quite distinct from each other, not blended and imbedded as in the older metamorphic rocks, and their mode of aggregation is also unlike. In addition to this, the occurrence of igneous products of very modern age, which are intimately associated with these rocks, and apparently prevail in great quantity, induce us to regard all these as belonging to a system of eruption and of elevation of very modern date.

We may, however, inquire what other evidences, if any, we have in the surrounding rocks as to the age of these igneous mountain ranges. The great table-land formed of the cretaceous rocks has on its eastern margin an elevation of not far from 1,000 feet. The surface of the country gradually rises to the westward, and near its junction with the igneous rocks of the Limpia range they have an elevation of 3,000 or more feet. On approaching the range, also, we find these beds of cretaceous age dipping at a high angle in various directions, showing great disturbance of the beds, apparently due to the elevation of intruded igneous masses. The beds of cretaceous rock have in some instances been indurated, and otherwise affected by the proximity or contact of igneous masses.

We have, therefore, not only evidence of the general elevation of the country towards the great central range in the inclination of these beds, but we have the positive evidence of local disturbance and change due to the intrusion of these igneous masses which form isolated points or mountain chains.

Beyond the Limpia range, in the neighborhood of El Paso, we have cretaceous rocks, containing numerous fossils. These beds rest upon carboniferous limestone, and all have a westerly dip—the carboniferous strata dipping at a much higher angle than the cretaceous. The rocks of both periods are complicated with volcanic and other igneous rocks; and in some instances the latter have been protruded beneath the cretaceous beds, and rest upon the carboniferous limestone, which is but partially altered. The cretaceous beds of this locality are about 4,000 feet above tide water.

Still farther west, in the vicinity of Corrilitas, cretaceous beds occur in connexion with partially altered limestones and igneous rocks, having an elevation of nearly 5,000 feet above the level of the sea. This is the most westerly point at which any cretaceous fossils have been found on the line of this expedition.

The occurrence of cretaceous deposits in this region is of much interest when taken in connexion with similar discoveries further to the northward. Captain Frémont, in his explorations of 1843 and 1844, brought cretaceous fossils from the eastern slope of the Rocky mountains, Smoky Hill Fork of the Kansas river, in latitude 39°, longitude 105°. In the explorations of 1846 and 1847, Lieutenant Abert collected specimens of the same species of cretaceous fossils, (*Inoceramus mytiloides*, = *I. problematicus*,) at Poblazon, on the western slope of the Rocky Mountains, in latitude 35° 13′, longitude 107° 0′ 2″.*

* Professor Bailey, who identified the fossils in Lieutenant Abert's collection, makes the following remarks: "The fossils from Poblazon consist of gigantic Hippurites, casts from the cells of several species of Ammonites, valves of Inoceramus, identical with a species figured in Frémont's Report, pl. IV, fig. 2,† casts of small univalves and bivalves too imperfect for

† *Inoceramus (mytiloides) problematicus.*

The same species of *Inoceramus* was brought from between the Big and Little Blue rivers, (tributaries of the Kansas river,) by Captain Stansbury. A collection from several points in Arkansas, made by Colonel Frémont in his late expedition, and sent to me for examination in 1854, contains also specimens of *Inoceramus problematicus*, associated with a few other fossils.

The cretaceous fossils which occur in the vicinity of Corrilitas correspond in position, being on the eastern slope of the Rocky Mountains in nearly the same meridian of longitude, and between 31° and 32° of latitude. In each of these explorations the points mentioned were the farthest west at which cretaceous rocks with fossils were obtained.

The identity of fossils, the occurrence of the same species of Inoceramus in all these localities, and its association at Poblazon with Hippurites, as in the collections of the Boundary Survey, indicate very clearly the same geological horizon for the strata of all these localities from the Kansas river to New Mexico.

The dip of the strata in the localities is influenced by the igneous rocks in immediate proximity, and is therefore variable, often inclining to the west; while the general dip of the formation is in the opposite direction.*

To the west of the last named localities there occur various stratified, partially metamorphic rocks, some of which may be of cretaceous age; but the information possessed warrants no more than a probable inference. One of the specimens is a somewhat coarse and rather loosely aggregated calcareous gray sandstone, and another is a partially metamorphic silicious slate.

The principal features developed by this collection show the existence of a broad belt of cretaceous rocks, in almost uninterrupted continuity, along the Rio Grande, from below Laredo to beyond San Vincente. On either side are igneous rocks occupying a greater or less extent; and beyond the junction of the Rio Pecos these igneous belts become of more frequent occurrence and of greater extent. The older tertiary deposits occupy isolated basins in the cretaceous formation, and both are covered indiscriminately by the alluvium.

In many places, these drift or alluvial deposits, consisting of waterworn materials, with saline efflorescences, gypsum, &c., are spread out over large areas of the cretaceous formation which forms the fundamental rock of the Llano Estacado or Staked Plain.

The almost constant occurrence of the carboniferous limestone, with these igneous and metamorphic belts, along a great north and south extent, taken in connexion with our knowledge of the existence of this formation on the west and northwest of the Mississippi valley and in Arkansas, offers almost conclusive evidence that nearly or quite all the intermediate space is occupied by the same strata underlying the cretaceous formation.

We already know of a similar association of the carboniferous limestone, over a large extent of country, in the vicinity of the Great Salt Lake, and at intervals farther to the south; and the facts, in connexion, afford a very probable inference that it occurs in similar associations from the southern boundary of the United States, or latitude 28°, to above the 42d parallel.

determination, and teeth of sharks. These fossils prove that the strata from which they were taken belong to the cretaceous formation. The existence of vast beds of this formation on the east side of the Rocky Mountains, and extending from the upper Missouri to Texas, is well known. The occurrence of the same formation on the western side of the primary axis of the Rocky mountains, is quite interesting."

"The dip of the rocks at Poblazon is to the west, or from the Rocky Mountains; and this proves that these mountains have been elevated since the deposition of the cretaceous beds. It is, therefore, probable that the cretaceous beds on both sides of the Rocky Mountains were made by the same ocean."

* The inferences in regard to dip, &c., are founded on observations and sections furnished by Dr. C. C. Parry.

The relative position of these cretaceous beds is precisely the same throughout Texas that it is along the valley of the Mississippi river, in the States of Tennessee, Arkansas, Illinois, and Missouri, where they rest upon the upper carboniferous strata.

In an economical point of view, the most important results shown by this collection are the almost constant association of metalliferous products at the junction of the igneous with the metamorphic rocks of the carboniferous period, or perhaps sometimes with metamorphic rocks of more ancient date.

The collection of silver lead ores and copper ores, from different veins, with the associated rocks, show that they are always near the junction of the igneous formations, and the superincumbent more or less altered limestones. The metalliferous veins, it would appear, always penetrate the limestones, which vary in character from gray or grayish blue granular beds with fossils, to light colored or nearly white crystalline limestones. The specimens which can be identified are clearly of carboniferous age, though some erratic specimens show that the older Palæozoic limestones may enter into this combination; and possibly some of the cretaceous beds have become so altered as to be undistinguishable from the older rocks, though we have yet had no proof of extensive metamorphism in rocks of this age.

These circumstances, nevertheless, do not affect the general inferences regarding the metalliferous character of the rocks at or near the junction of the two systems. The facts before us warrant the conclusion that the conditions enumerated apply not only to the region actually travelled over, but also to the highly metalliferous regions farther to the south in the same range. These facts also suggest the importance of a more careful examination of this range in its northern extension, which we already know to have the same geological constitution, but which has scarcely been explored with a view to its economical resources.

OBSERVATIONS UPON THE IGNEOUS AND METAMORPHIC ROCKS, AND ASSOCIATED MINERALS, IN THE BOUNDARY SURVEY COLLECTIONS.

The preceding catalogue of specimens, with observations upon their character and geological age, and a resumé of their geographical distribution, may very properly be followed by some notice of their relative positions in the series, and their correspondence with, or difference from, others of the same age in other parts of the country.

From time to time, and from various sources, we have learned that large areas of the central portion of this continent are occupied by rocks of igneous or metamorphic character; and that the plains and valleys present geological formations of different and more recent periods. We have also been made aware of the entire distinctness, in character and origin, as well as geographical separation, of the great mountain chain of the Cordilleras, or Sierra Nevada of the North, from the more easterly ranges of the Rocky Mountains.

Physically, the great central mountain region, or Rocky Mountain chain, with its subordinate ranges, is clearly as distinct from the western chain, notwithstanding there may be numerous isolated peaks and short broken ranges, which form a partial connexion between them. Still, again, the Sierra Nevada and the coast range are recognized as geographically distinct.

Geology has likewise proved these several mountain ranges to be of different origin and of different age. The Cordilleras, or Sierra Nevada, and the subordinate ranges, or isolated mountains dependent upon that stupendous chain, are all of the older metamorphic rocks, consisting of stratified rocks of Palæozoic age, silurian, devonian, and perhaps, to some extent, of carboniferous strata, which have been changed from their original condition, and finally elevated into mountains. The lithological character and mineral products are identical with the rocks of the Appalachian chain, which form the great elevation from Canada and Nova Scotia to Alabama, on the eastern side of our continent. Their lithological characters and mineral products correspond likewise with rocks known to be of that age in other parts of the world.

The series of specimens in the boundary collections, and the specimens in other collections, brought from this mountain range, exhibit all the varieties of mineral materials and differences of aggregation presented in a series of the rocks of the Appalachian formations. The auriferous gravel of California is derived from the quartz veins in the slates and other rocks of the Sierra Nevada, as the auriferous gravels of Canada, Virginia, the Carolinas, and Georgia are derived from the quartz veins of the Appalachian rocks. The auriferous quartz veins of California are the same in character, in age, and origin, as those traversing the metamorphic rocks of the great eastern chain from Canada to Georgia.

There are even stronger, though more subtle, analogies between the rocks and minerals of these widely distant mountain regions, when submitted to the researches of the chemist. Rocks and compound minerals, while known by the same names, are often found, on careful analysis, to possess different proportions of certain elements; or they may in one case contain an elementary mineral substance not known in the other. Now, even in this regard, the researches of chemistry have proved that certain mineral products of the one mountain chain are precisely similar to the same in the other. And we might go still further, and show that the order of succession among beds of a certain character is the same in both mountain chains,

and prove also, by dynamic and chemical laws, that it could not have taken place in any other order.

The present occasion does not require the details of comparison between these two ranges of the same age. Still, it is not a little interesting to know that two mountain chains, produced from the metamorphism of series of strata of the same age, now form, the one the eastern, and the other the western, outlines of our continent. The one has a direction from northeast to southwest, and the other, almost at right angles, from the northwest to the southeast, giving us the great breadth of continent at the north, and the narrow southern extremity.

The coast range of mountains presents us with quite distinctive features in the specimens, and we know from many sources that it consists of recent igneous rocks and metamorphic strata of very modern age, the igneous products being chiefly greenstone or basalt, amygdaloid, and materials of similar character. Further east, the Cordilleras offer a striking contrast in the collections to those made along the route travelled from the coast of Texas to the westward. From the coast to the Rio Grande, the specimens from the Limpia range, from the Sierra Madre, and the Organ Mountains present no character similar to those from the Cordilleras. The granites are all of different aspect, with glassy feldspar, occuring in connexion with known volcanic products, as porphyry, greenstone, and mixtures of quartz, feldspar, and olivine, etc.

There are among these no granites assuming a gneissoid structure; no granites with shorl, tourmaline, or garnets; no talcous (pholerite) slates, chloritic or mica slate rocks, as in the Cordilleras. The lithological aspect of the two collections is at once conclusive of their different age and origin.

Whatever the Rocky Mountains may offer in other parts of their range, that passed over in the boundary survey gives no indication of the occurrence of the older metamorphic rocks. Indeed, the materials of purely igneous origin so largely preponderate, that the few metamorphic specimens appear quite subordinate; while the observations accompanying the igneous specimens prove that they form nearly entire mountains which are crossed upon the route.

We are aware that further to the north there are extensive mountains, which bear rather the character of metamorphic than of igneous products; but even these do not resemble the metamorphic rocks of the western chain.

In the specimens from this range, we see the predominating influence of volcanic action, and the result of the same action in the influence of heated waters holding silex in solution, by which the more porous masses have been penetrated and become solid, or so changed in color and condition that there is an almost infinite variety of these products of one prime source.

OBSERVATIONS ON THE CARBONIFEROUS LIMESTONE OF THE BOUNDARY SURVEY COLLECTIONS, AND ITS RELATIONS WITH THE CARBONIFEROUS LIMESTONES OF THE MISSISSIPPI VALLEY.

The carboniferous limestone, so often mentioned in the preceding pages, and which has been usually referred to in published reports as "Carboniferous limestone," and as "Lower carboniferous limestone," is actually of the same age as the coal measures. This point we have but lately had the means of satisfactorily determining.

Several species of fossils were known to characterize this formation over a wide extent of country, and from their associations the rock was referred simply to "carboniferous limestone,"* without distinguishing the order of position among the different members of that series. Among these species were several known to occur in the coal measures of Ohio, Indiana, Illinois, Iowa, and Missouri, while none of them were characteristic of the lower carboniferous limestones.

In the Missouri Geological Report of 1855, Professor Swallow has placed the limestones and shales of Weston and other localities, which contain these fossils, in the upper coal measures. At the same time, some of them are known to occur in the lower coal measures; and, with our present knowledge, we are constrained to believe that certain species occur both in the upper and lower coal measures of the west.

In order to understand fully the relations of this higher carboniferous limestone of the west to the other members of the series termed carboniferous, it is necessary to present the following section of these rocks, beginning with the upper member:

	Section of the carboniferous limestones and the coal measures in the valley of the Mississippi.	LOCALITIES.
VII.	Shales, shaly sandstones, sandstones, and seams of coal, with shaly and more compact limestone, constituting the *upper* coal measures. This limestone is designated as the *upper carboniferous limestone*, and constitutes the carboniferous limestone of the Rocky Mountains.	*Localities of the upper carboniferous limestone*, Ohio; Indiana. Illinois; Weston and Bellevue, Missouri; Great Salt Lake, Utah Territory; near Santa Fé, and at the Pecos village, New Mexico, etc.
VII.	Coal measures below the limestone, being the *middle* and *lower* coal measures of the Missouri report, and the *lower* coal measures, in part, of Ohio and Pennsylvania.	Ohio, Indiana, Illinois, Missouri, etc.
VI.	—Kaskaskia, or Upper Archimedes limestone	Kaskaskia and Chester, Illinois; St. Mary's, Missouri, etc
V.	—Gray, brown, or ferruginous sandstone	Below St. Genevieve, Missouri, between Prairie du Rocher and Kaskaskia, Illinois.
IV.	—St. Louis limestone, or concretionary limestone	St. Louis, St. Genevieve, Missouri; Alton, Illinois; highest beds below Keokuk, Iowa.
III.	Arenaceous bed	Warsaw and Alton, Illinois; Spergen Hill, Bloomington, Ind.
III.	Warsaw, or second Archimedes limestone	Warsaw and Alton, Illinois; Spergen Hill, Bloomington, Ind.
III.	Magnesian limestone	Warsaw and Alton, Illinois; Spergen Hill, Bloomington, Ind.
	Beds of passage, shale or marl, with geodes of quartz, etc.	Keokuk, Iowa; Warsaw, Illinois
II.	—Keokuk limestone, or Lower Archimedes limestone	Keokuk, Iowa; Quincy, Illinois; above St. Genevieve, Mo.
	Beds of passage, (cherty beds,) 60 to 100 feet	Rapids of the Mississippi, above Keokuk
I.	—Burlington limestone	Burlington, Iowa; Quincy, Illinois; Hannibal, etc., Missouri.
	Oolitic limestone and argillaceous sandstone of the Chemung period.	Burlington, Iowa; Hannibal, Missouri.

* Dr. Owen in his report upon the Chippewa land district, gives numerous sections of the carboniferous limestone in the Mississippi and Missouri valleys, and its connexion with beds of coal; but he does not speak positively with regard to the position of this rock or its distinction from the carboniferous limestones below.

The limestones in the lower part of the section are those usually termed "carboniferous limestone." The group consists of distinct members, each marked by numerous characteristic fossils, and the whole together representing the phases of a calcareous formation, going on in an ocean, where the conditions of its bed and its limits were subjected to change.

The limestones of this period are well developed in the valley of the Mississippi, from above Burlington, in Iowa, and Oquaka, in Illinois, as far south as below the towns of Kaskaskia and Chester, on the Illinois side, and St. Genevieve and St. Mary's, on the Missouri side. Several of the members are known in Indiana, and one or more in Kentucky, Tennessee, and Alabama, and also in Arkansas. Throughout all this region these limestones, whether developed as the full series or in a single member, underlie the coal measures proper.

In all the collections which I have examined from Texas and New Mexico, and from points further north in the same line, and particularly in the collections made by Captain Stansbury, on his route from the Missouri to the Great Salt Lake, and in that region, I have never observed fossils which are characteristic of any member of the lower carboniferous limestone. We have, thus far, no evidence of the occurrence of lower carboniferous strata among the Rocky mountains; while at intervals from the northern limits of the United States along the range of the Rocky Mountains, and both east and west of the principal range, we have the upper carboniferous limestone everywhere more or less perfectly indicated by its characteristic fossils. Among these are *Spirifer cameratus*, *S. lineatus*, *Terebratula subtilita*, *Productus Rogersi*, *P. semireticulatus*, *Zaphrentis Stansburyi*, and others. From a recent comparison of specimens from Ohio, Illinois, Iowa, Missouri, Kansas, Texas, and New Mexico, I find the same association of species from numerous localities.*

In the eastern and northern part of the State of Ohio, (and perhaps extending into Pennsylvania,) there are thin bands of limestone associated with the coal measures. These beds are usually shaly in character, often separated by wide vertical joints, and weather to a brown color. Although recognized at numerous points, I am not aware that these beds have been regarded as continuous, though they are doubtless indications of a continuous formation. A comparison of fossils from numerous points in the coal measures of the West, shows very conclusively that one or more of these beds of limestone are continuous, or at least that the same association of fossil species occur at so many points as to leave no doubt of a similarity in the conditions of the ocean bed over a wide area now occupied by the coal measures.

One of these bands of shaly limestone, containing throughout the same species of fossils, may be traced from northeastern Ohio, or even from Pennsylvania, through Indiana, Illinois, Iowa, and Missouri, becoming in the latter State, and in the adjoining parts of Nebraska and Kansas, an important limestone formation, and constantly increasing in a westerly direction until it becomes the prominent limestone of the Rocky Mountain range.

According to the report of Captain Stansbury, and from specimens brought by him from the Salt Lake region, we learn that it there forms extensive mountain ranges or at least that it is

* It was from a limestone in the coal measures of Ohio that Dr. Hildreth procured several species of fossils which are described by Dr. Morton in the American Journal of Science, vol. xxix. The *Spirifer cameratus* of that paper appears to be identical with one described by Dr. Roemer as *S. Meusebachanus*, and by the writer as *S. triplicatus*, in Stansbury's report, and the same is referred, with doubt, by Dr. Owen to *Spirifer fasciger* of Keyserling. The species presents much variety in different localities, but a comparison of specimens from Ohio, Iowa, Missouri, Texas, and New Mexico, leads me to infer that they are all of a single species first described by Dr. Morton. It is possible that further comparisons may show the occurrence of two closely allied species, but more extensive collections are required for this purpose.

the most conspicuous rock of the north and south ranges in the vicinity of the Great Salt Lake. The limestone from these localities is a dark-blue, compact rock, often, in specimens, gray and subcrystalline, and sometimes with sparry veins.

This limestone, identifed by its fossils, is found in the collections made near Santa Fé, New Mexico, at the Pecos village, the Mogollan Mountains, at El Paso, upon the river San Pedro, and the numerous other localities. From a sketch and the notes of Dr. Parry, before alluded to, this limestone forms a conspicuous part of some of the mountains along the boundary line. There can be little doubt that the same limestone occurs much further to the southward, and that it constitutes the principal calcareous formation of that part of the country, whether in an unaltered or in a metamorphic condition. It is, as already stated, the limestone traversed by veins of silver lead, from which specimens have been brought in the boundary collection.

The collections of Dr. Roemer, from Texas, indicate very clearly the occurrence of this limestone at the places examined by him; and he gives no figures of species belonging to lower carboniferous limestones.

From the massiveness and compact texture of many of the specimens from the southwest, and the subcrystalline character of others, we are prepared to find that this rock has become much more extensively developed than in the northeast, or even in Missouri or Kansas; and it would appear, also, that the shaly beds which accompany the limestone in these localities and are often more conspicuous than the limestone itself, have diminished so far as to form no striking feature in the far west and southwest. We are not able to learn that it is there ever accompanied by coal, and it is presumed that the shaly and sandy materials associated with the coal, as well as the coal itself, have thinned out in that direction, or become of such tenuity as to be of no importance.

The relations of this limestone to the lower coal measures, in the States bordering the Mississippi river, render its occurrence a subject of interesting economical inquiry. Since we know that the most extensive and valuable beds of coal in the west are of the lower coal measures which lie beneath the upper limestone, they may still be found to underlie the upper carboniferous limestone of the Rocky Mountains, as they do the same limestones in Kansas, Missouri, Iowa, Illinois, and Indiana. Thus far I am not aware that any inquiries of this kind have been instituted in the explorations and surveys already made.

Having thus briefly described the range of the upper carboniferous limestone, we may now take a comprehensive view of its conditions and extent. We find that during the coal period, in the States east of the Mississippi river, thin strata of limestone, or calcareous shale, were deposited. These are charged with brachiopoda, of genera characterizing the carboniferous limestone below the coal measures, though of species distinct and peculiar. So thin and insignificant is this formation, that we can scarcely regard it as the product of a wide and deep ocean. Tracing it westward, however, its importance increases; from being entirely subordinate to the coal measures proper, and scarcely affecting the character of that formation, it becomes a characteristic mass; the calcareous mud mingles with the coal, and the latter becomes subordinate to the limestone and calcareous shales. Still further west it is a vast limestone formation, next in importance to the great calcareous formation below the coal, or lower carboniferous limestone formation.

The conditions favorable to the production of an extensive deposit of marine limestone are

not such as usually accompany the production of coal. In the present instance, the ocean, depositing the great limestone formations previous to the coal period, occupied to a great extent the present area of the coal measures which succeeded. Land plants in excessive growth, estuary or shallow water shells attend the production of the coal and its associated strata. We begin thus to comprehend the truth that, during the period of the great coal formations of the Appalachian, and the Mississippi valley, there existed a broad ocean at the far west and southwest, in which these calcareous deposits were in course of formation; that during the oscillations which we know to have occurred throughout the coal period, there was a time when the whole area became depressed so as to allow the waters of the southwestern ocean to flow over all the coal-measure area, or, at least, as far northward and eastward as the northeastern part of Ohio; and from hence is derived the limestone under consideration. The calcareous bands deposited along the northeastern margin of this ocean, we now find interstratified with seams of coal, and beds of shale and sandstone containing land plants; while, as the waters deepened towards the southwest, the formation exhibits the differences of character which we would necessarily expect to find in an ocean deposit.

The evidence of the existence of this ocean in the far west and southwest, during the coal period, amounts to almost a proof that the conditions of that area, which now constitutes a part of the continent, were never such as to admit of the production of coal plants, and the deposit of such materials as make up the coal measures, at least during the latter part of the coal period. In regard to the earlier part of that period, or the time in which the lower coal measures were formed, we have not, as I conceive, at present, the means of fully deciding what were the conditions in the central and southwestern part of our continent.

OBSERVATIONS UPON THE CRETACEOUS STRATA OF THE UNITED STATES, WITH REFERENCE TO THE RELATIVE POSITION OF THE FOSSILS COLLECTED BY THE BOUNDARY COMMISSION.

The list of fossil species from the localities visited by the Boundary Commission shows so large a number identical with those described and figured by Dr. Roemer in his *Kreidebildungen von Texas*, that we cannot doubt the occurrence of the same beds throughout the whole extent surveyed, as far as the neighborhood of El Paso and Frontera. These collections, made at intervals over so wide an extent, would be likely to give us some representative species from different and successive beds of the formation, should it there exhibit similar subdivisions as are elsewhere known in this formation, in other parts of the country. With the exception of two species, they are all distinct from those known in the cretaceous formation of New Jersey and Alabama, where the fossils have been most carefully studied. They are equally distinct from the species occurring in Nebraska; while those from the last-named region present so many species in common with New Jersey and Alabama, that we cannot doubt the general equivalency of the beds in these distant points. The species known from Tennessee are likewise identical with New Jersey species to a great extent, leaving no doubt as to the exact equivalency of the formation in the two localities.

The cretaceous formation, as known in New Jersey, can therefore be traced by the Atlantic coast to Alabama, and thence into Tennessee, and even southern Illinois; and though not yet followed continuously to the northward, it is nevertheless recognized in Nebraska by numerous identical species of fossils.

When we carry forward our investigations in a southwesterly direction, however, we soon lose, to a great extent, the evidence of identity in the fossils; and in Arkansas the *Exogyra costata*, *Ostrea vesicularis*, and *Trigonia thoracica*, are almost the only species identical with those known on the east of the Mississippi river, and in Nebraska. At the same time, other species occur in considerable abundance, which are of decidedly cretaceous character, leaving no doubt of the existence of that formation, though we have lost the evidences which guide us in more eastern localities.

Since this change in the character of the fossils is quite observable as far north as Fort Washita, in Arkansas; and since the types of the green sand of New Jersey and Alabama extend as far north as Tennessee and Illinois, it is clear that the change is not due to climatic influence or to geographical distance. It would moreover be unreasonable to suppose that such a change in the nature of the sediment had taken place as to destroy within this short distance all the forms of life so well known further east, and replace them with others adapted to the different condition. Indeed, we are not informed that there is any great change in the lithological character of the strata; though it is true that the cretaceous beds of Arkansas, Texas, and New Mexico, (as we judge from the specimens,) are more calcareous than those of New Jersey and Nebraska. But they are not more so than in Alabama, where the "Rotten limestone" attains a thickness of 400 feet, and contains species common to the regions just referred to.

It is not due therefore to difference of latitude, or to a change of conditions in the sediment,

that we have this difference in the organic remains of the formation; but it is doubtless true that this region of the cretaceous formation of the southwest, which has yielded nearly all the fossils, represents a *different epoch* in the *cretaceous period* from those beds further east and in the northwest, of which the organic contents are better known.

The relations of that part of the cretaceous formation, which is developed in Texas and New Mexico, to the same formation as known on the east of the Mississippi river and in Nebraska, becomes a matter of much interest and importance.

The various examinations in Texas and in Arkansas, as well as along several lines of survey, do not give us any sections of these beds showing their relations with other formations, or indications that there may be more than a single member of the cretaceous formation from which all these fossils have been derived.

Before attempting to theorize in regard to the probable cause of this difference in the fossils of the cretaceous strata at these distant points, we may bring together in a general manner the results of investigations made at various points and at different times, which may serve to throw some light upon this question.

In the earlier investigations of the cretaceous formations of New Jersey and other parts of the United States, Dr. Morton subdivided the whole into three groups or divisions.

First Group.—Upper cretaceous strata.

Second Group.—Medial cretaceous strata.

Third Group.—Lower cretaceous strata.

The upper division embraced the Nummulite limestone of Alabama, being especially characterized by the presence of *Plagiostoma dumosum*, *Nummulites Mantellii*, (*Orbitoides Mantelli.*) This rock is now regarded as belonging to the older Tertiary formations.

The medial division was regarded as contemporaneous with the white chalk of Europe.

The lower division embraced the "ferruginous sand deposits of the Atlantic States, extending from Martha's Vineyard to South Carolina and Alabama, and into Mississippi, Arkansas and Missouri."

These strata were at that time regarded as contemporaneous with those which lie between the white chalk and oolite in Europe.

The foregoing subdivisions were proposed by Dr. Morton in some "additional observations" appended to his "Synopsis of the organic remains of the cretaceous group of the United States," and published in the Journal of the Academy of Natural Sciences in 1842. Accompanying this classification of the cretaceous formation is a list of fossils from each of the subdivisions, including all those which had been described up to that period.

Professor Rogers, in his report upon the geology of New Jersey, in 1840, proposed a division of the cretaceous formation of the State into five members. These subdivisions, however useful they may have been topographically, are not accompanied by the palæontological evidence necessary to enable us to determine their value as distinctive groups, or to aid us in a comparison with the sequence in other localities.

More recently the investigations made during the geological survey of the State of New Jersey have thrown further light upon the order of succession, and the lithological character of the members composing the green sand formation of New Jersey. The section given by Professor Cook, which has been verified by borings in several places, leaves no doubt that we have now arrived at a knowledge of the true relations of the different members of this period as

developed in New Jersey; and it is the more interesting since it enables us to show the true position of certain well marked and widely distributed cretaceous fossils, in relation to others which approximate in character to Tertiary types.

The following section gives the expression of all that is at present known regarding the order of succession among the members of the system as they occur in eastern New Jersey.*

		Divisions, lithological characters, etc.	General remarks, sub-divisions, etc.	Characteristic fossils, etc.
	VIII	Green sand, 3d or upper bed.	This bed admits of a triple division, the central portion is nearly destitute of fossils, while those of the upper and lower divisions are mostly dissimilar.	
	VII	Quartzose sand, resembling beach sand.	This bed is (so far as known) quite destitute of fossils.	
Equivalent to Nos. 4 and 5 of the Nebraska section.	VI	Green sand, 2d bed.	(a) Yellow limestone of Timber creek.......	(a) Characterized by *Eschara digitata*, *Montivaltia* (*Anthophyllum*) *atlanticum*, *Nucleolites crucifer*, *Ananchytes cinctus*, *A. fimbriatus*, Morton.
			(b) A bed of nearly unchanged shells........	(b) Among the characteristic fossils of this bed are *Gryphœa vomer*, *G. convexa*, and *Terebratula Harlani*.
			(c) Green sand, etc......................	(c) *Cucullea vulgaris* is the most characteristic fossil of the lower division.
	V	Quartzose sand, highly ferruginous throughout, and argillaceous in its upper part.	This rock is sometimes indurated or cemented by oxide of iron.	*Exogyra costata*, *Ostrea larva*, *Bellemnitella mucronata*, *Pecten* (*Neithea*) *quinquecostatus?* and many other fossils, mostly in the condition of casts of the interior, or impressions of the exterior.
	IV	Green sand, 1st or lower bed.	Several subdivisions may be recognized, depending on the character of the marl, etc.	*Exogyra costata*, *Orstrea larva*, *Bellemnitella mucronata*, *Terebratula Sayi*, (*Gryphœa convexa* and *G. mutabilis*) *Ostrea vesicularis*.
	III	Dark colored clay, containing green sand in irregular stripes and spots.		*Ammonites Delawarensis*, *Ammonites placenta*, *A. conradi*, *Baculites ovatus*, casts of *Cardium*.
			Position of beds Nos. 2 and 3 of the Nebraska section.	
	II	Dark colored clay.......	At the present time the evidence tends to show that No. 1 of the Nebraska section is represented here by Nos. 1 and 2, and that Nos. 2 and 3 of the Nebraska section are wanting, and would find a place between Nos. 2 and 3 of this section, if existing.	This bed contains large quantities of fossil wood, (no animal remains are known to occur in it.)
	I	Fire clay and potters' clay.	....	This bed contains fossil wood and numerous impressions of leaves, but no animal remains.
		Gneiss.		

In Alabama, according to the report of Professor Tuomey, the cretaceous strata admit of a

* This section has been communicated to me by Professor George H. Cook, of the New Jersey Geological Survey, and gives some additional information beyond that already published in his Geological Report.

three-fold division, in which the upper member consists of the "rotten limestone," the central an arenaceous group, and a lower dark colored clay.

Without at present having the means of exact comparison, it may be inferred that there is a close agreement between the different members of the series in Alabama and New Jersey. The specific identity of many of the characteristic fossils leaves no doubt as to the close similarity of the formation there developed, with the beds in New Jersey, from which a large part of the fossils described by Dr. Morton were obtained. The calcareous part of the formation in Alabama acquires a far greater development than in New Jersey, and appears to be there the principal repository of the fossils of this period.

It is now more than fifty years since Messrs. Lewis and Clark, in their expedition to the Columbia river, brought from the Great Bend of the Missouri river some fossils, which were afterwards identified by Dr. Morton as belonging to the cretaceous formation, and from beds of the same age as the marl or ferruginous sand of New Jersey, Delaware, and Alabama. Subsequently Mr. Nuttall brought some species from the same locality. Dr. Morton, in his Synopsis, (1834,) acknowledges the receipt of *Gryphœa Pitcheri* and other cretaceous fossils of great interest, from the plains of Kiamesha, in Arkansas, from Dr. Z. Pitcher, of the United States army. Dr. Morton also mentions other fossils from the falls of Verdigris river, in the same Territory.

It is nearly twenty years since Mr. Nicollet first visited and explored the country about the sources of the Mississippi and some parts of the Missouri river, as far up as Fort Pierre. The collections made by this gentleman enabled Dr. Morton to designate about sixteen species of cretaceous fossils, half of which were regarded as common to that region, New Jersey, and Alabama. Mr. Nicollet, in his report, has given the following section of the beds of the cretaceous formation upon the Upper Missouri:

D.—A plastic clay deposit, about 200 feet thick, divided into two equal parts by a stratum of carbonate of lime in nodules.

C.—A ferruginous clay, of a yellowish color, containing masses resembling septaria and seams of selenite.

B.—A calcareous marl, generally from 30 to 40 feet thick.

A.—"Argillaceous limestone, containing *Inoceramus Barabini* (?) in great numbers, and very much compressed, and so arranged as to give the rock a slaty appearance."*—(At Dixon's Bluff.)

The importance of these divisions does not appear to have been fully appreciated, or the collection was not sufficient to establish the restriction of species within the limits thus indicated.

In the meantime, the explorations of Lieutenant Frémont, of Lieutenant Abert, of Captain Stansbury, and others, and more extended examinations made under the direction of Dr. D. D. Owen, in his Geological Survey of the Chippewa Land District, have brought to light other cretaceous species from this region;† while the several Pacific railroad surveys have shown the occurrence of cretaceous fossils at various points farther to the south, and at intervals which indicate a continuation of the formation from the Missouri river to New Mexico. More recently, Dr. Evans, who had previously visited this region as assistant in the geological survey of Dr.

* The species of Inoceramus in Mr. Nicollet's collection, in a condition here described, was subsequently identified by me as the same with that brought by Captain Frémont from the Smoky Hill river.—(See report, p. 310.)

† In his report Dr. Owen does not notice the subdivisions of Mr. Nicollet's section; and the cretaceous species figured and described appear all to have been derived from a single bed of the formation.

Owen, has collected, and with Dr. B. F. Shumard, has described, several new cretaceous species from the same region.

In 1853, Messrs. F. B. Meek and F. V. Hayden made an extensive collection of the fossils of the cretaceous formation upon the Missouri river in Nebraska; and among these somewhat more than thirty new species, a number equal to all the cretaceous species before known as occurring in that region. These species were described by the writer, in connexion with Mr. Meek, in the Memoirs of the American Academy of Arts and Sciences.* A section of the cretaceous and tertiary strata of the Missouri river and the Mauvaises Terres, compiled from the notes of Mr. Meek, made upon the ground and verified by subsequent examination of the fossils, likewise accompanied the paper just noticed, on page 405 of the same volume.

The order of succession among the beds constituting the cretaceous formation, and their lithological character there established, are as follows:

Section of the members of the cretaceous formation, as observed on the Missouri and thence westward, including the tertiary beds of the Mauvaises Terres.

Tertiary formation			Indurated clays, beds of sandstone, conglomerate, limestone, &c., containing remains of Mammalia and Chelonia, with a few species of fresh water shells.
Cretaceous formation of Nebraska.	Equivalent of Nos. III, IV, V, and VI of the New Jersey section.	C and D of Nicollet's section.	V.—Arenaceous clay, passing into argillo-calcareous sandstone; 80 feet thick.
			IV.—Plastic clay, with calcareous concretions, containing numerous fossils; 250 to 300 feet thick. (This is the principal fossiliferous bed of the cretaceous formation upon the upper Missouri.)
		A and B of Nicollet's section.	III.—Calcareous marl, containing *Ostrea congesta*, *Inoceramus problematicus*,† scales of fishes, &c.; 100 to 150 feet thick.
			II.—Clay containing few fossils; 80 feet thick.
			I.—Sandstone and clay; 90 feet. The probable equivalent of Nos. I and II of the New Jersey section.
Carboniferous formation			I.—The sandstone, No. I of section, rests upon buff colored magnesian limestone of the upper carboniferous period.

In this section Nos. II and III correspond to A and B of Mr. Nicollet's section, while the sandstone, No. I, was either overlooked by him, or may have been referred to the carboniferous strata.‡

The divisions C and D of Mr. Nicollet's sections are subdivisions of Nos. IV and V of our section, or probably of No. IV alone, since No. V is not known to occur on that part of the

* "Description of New Species of Fossils from the Cretaceous Formation, by James Hall and F. B. Meek. Memoirs of the American Academy of Arts and Sciences, vol. V, new series.

† In a subsequent exploration of this region Dr. Hayden discovered *Inoceramus problematicus* in this bed, in precisely the same conditions and in a rock identical with that in which the specimens occur brought by Captain Frémont from the Smoky Hill river, and by Captain Stansbury from between the Big and Little Blue rivers.

A careful comparison of *Inoceramus fragilis*, from bed No. 2, Nebraska section, (Hall and Meek, Memoirs Amer. Acad., vol. V, new series, page 388,) has satisfied both Mr. Meek and myself that it is identical with *I. problematicus*, the specimen described being the young of that species. The young specimens of the latter shell from Arkansas and Smoky Hill river present no essential differences from those of Nebraska.

Dr. Hayden has likewise made extensive collections in other parts of the Nebraska cretaceous and tertiary formations during the past two years. The new species of these collections have been described by Messrs. Meek and Hayden, in several papers published in the proceedings of the Academy of Natural Sciences of Philadelphia. These explorations, with the extensive collections of fossils, have served to sustain the correctness of the order of succession among the subordinate members of the series as given in the section above; indicating, however, that the beds Nos. II and III, as well as Nos. IV and V, may in some localities merge into each other; while the limits between Nos. III and IV remain well marked throughout the region explored.

‡ From the fact that Mr. Nicollet remarks, (page 35,) that the part of stratum A above water, on the day of his "examination, was three feet," we may infer that the sandstone No. I was not seen by him.

Missouri which was examined by Mr. Nicollet. Although admitting of several subdivisions from changes in lithological character, the beds of No. IV do not present any groups of fossil species restricted within the physical or lithological limits designated, and they can scarcely, therefore, be regarded as of importance in the classification of the formation, or valuable in tracing the limits of its members over a wide extent of country.

The subdivisions A and B, corresponding to Nos. II and III of our section, are more important; and, although yielding so few fossils on the Missouri, they become well marked in other parts of the country. The "*Inoceramus Barabini*," represented by Mr. Nicollet as found in great numbers at Dixon's Bluff, very much compressed and so arranged as to give the rock "a slaty structure," is undoubtedly the *Inoceramus problematicus*, which is known to occur in this position, and does not occur in the higher beds of the formation upon the Missouri, so far as known at the present time. The *Ostrea congesta*, and all the other fossils from beds Nos. II and III of the section, are unlike species from New Jersey or Alabama, and appear to be restricted to these beds. At the same time the species identical with or analogous to species of New Jersey and Alabama occur in beds Nos. IV and V, which may perhaps be regarded as subdivisions of one group.

We are warranted, therefore, in referring the beds above No. III to the fossiliferous beds of New Jersey and Alabama, while we have yet no evidence that Nos. II and III do occur in either of these States.

The beds Nos. III, IV, V, and VI of the New Jersey section, given on a preceding page, correspond in their fossils with Nos. IV and V of the Nebraska section; leaving the third green sand of New Jersey (No. VIII of that section) unrepresented in the northwest, so far as known at the present time.

The New Jersey beds, Nos. I and II, which are marked only by fossil wood and impressions of leaves, appear to be represented by No. I of the Nebraska section, judging from the general character of the remains yet known in the two. Should this inference prove to be correct, the beds Nos. II and III of the Nebraska section will hold a position between Nos. II and III of the New Jersey section; but I do not regard this question as yet determined.

The relations of the beds Nos. II and III of the Nebraska section, and their characteristic fossils, become very important when we undertake the comparison of the cretaceous formation of Texas and New Mexico with that of Nebraska, Alabama, and New Jersey.

The wide extent and persistence of *Inoceramus problematicus*, and its restriction to beds Nos. 2 and 3, and their equivalents, so far as at present known, render it of great value in determining a geological horizon. This species was first brought from the Missouri river by Mr. Nicollet.* It was collected by Captain, now Colonel, Frémont † upon the Smoky Hill Fork, where it occurs in a gray or buff color, and also in a blue, slaty limestone in great numbers, and being extremely flattened, gives to the rock a slaty structure, as described by Mr. Nicollet.

* Report on the Upper Mississippi River, by J. N. Nicollet, 1853.

† Report of the Exploring Expedition to the Rocky Mountains, by Captain J. C. Frémont, 1854. Appendix, geological formations and organic remains, by James Hall. At the time of my examination of Captain Frémont's collections, I had an opportunity of comparing the specimens of *Inoceramus* with those brought from the Missouri by Mr. Nicollet, and identified the specimens in the two collections as the same species. The collections of Mr. Nicollet were, at that time, broken up, and I saw some of them in Professor Ducatel's possession, in Baltimore, and others in Georgetown. The information given me was, that they were from near the Great Bend of the Missouri; but by the examination of Mr. Nicollet's report, it is very clear, from his statements, page 35, that this *Inoceramus* occurs at Dixon's Bluff, and not at Great Bend, since Mr. Nicollet refers to the former locality as exhibiting the base of the formation.

The specimens collected by Lieutenant Abert,* at Poblazon, are doubtless of this species, and are referred by Professor Bailey to the same species as those of Frémont's report. The same species was brought by Captain Stansbury † from between the Big and Little Blue rivers, in precisely the same conditions, and in a similar rock. In 1854 I received specimens of the same fossil, collected at several points on the Arkansas, by Colonel Frémont, during his later expedition. These occur in part in a bluish, or dull lead-colored, argillaceous limestone, and others in a gray or buff-colored limestone.

Dr. Schiell collected this species of *Inoceramus* at the bend of the Arkansas river; and it is mentioned by Dr. Roemer as occurring near New Braunfels, in Texas. Dr. F. V. Hayden has, more recently, brought the same from the bed No. 3, Nebraska.

In Arkansas, this fossil is collected from the same localities, and apparently in the same position from which are obtained numerous species of *Echinoderms*, *Gryphœa Pitcheri*, and other fossils of species yet unknown in Nebraska, or in any localities east of the Mississippi river.

Fragments of the same species of *Inoceramus* occur in an argillaceous limestone, among the collections of the Boundary Survey, from the basin of the Rio Grande. In the same connexion occur several *Echinoderms* of species identical with those from Arkansas--*Gryphœa Pitcheri*, *Ammonites Texanus*, etc.

The collections of the Pacific Railroad Surveys, which have been placed in my hands for examination, show that *Ostrea congesta* was collected by Mr. Marcou, from a point three miles north of Galisteo, between Fort Smith and Santa Fé.‡ This fossil, in Nebraska, is associated with *Inoceramus problematicus*. In the same collection, and from the same locality, near Galisteo, there were specimens of a slaty limestone containing fragments of *Inoceramus*, which, although not identified at the time, is probably the *Inoceramus problematicus*. Thus we have abundant evidence of the distribution of this species from Nebraska to New Mexico.

The section already established for the cretaceous strata upon the Missouri, as given above, and the occurrence of *Inoceramus problematicus* in the beds Nos. 2 and 3 of that section, serve to fix the place of that fossil in the series in reference to the other beds constituting the cretaceous formation in Nebraska. From the analogy of the beds Nos. 4 and 5, and the identity of several important species of fossils with those of New Jersey, Alabama, and Tennessee, we may regard the position of this fossil as determined in reference to the members of the series which occur in these States, this species having never been found, so far as we are aware, in either New Jersey, Alabama, or Tennessee. Thus this fossil becomes one of the best guides for the identification of certain strata in the cretaceous system of the United States.

In a paper recently published in the proceedings of the Academy of Natural Sciences, by Messrs. Meek and Hayden, speaking of the geographical distribution of the cretaceous fossils, they refer to the well known species *Ammonites placenta*, *Scaphites Conradi*, *Baculites ovatus*, and *Nautilus Dekayi*, as being common to the central or upper portions of New Jersey cretaceous strata, to the rotten limestone of Alabama, and to beds Nos. 4 and 5 of Nebraska. Alluding to the position of the cretaceous beds of the southwest, they remark:

"At the same time the total absence of the above named fossils, and, indeed, so far as we yet

* Report on a Geographical Examination of New Mexico, by Lieutenant J. W. Abert, 1848. Notes concerning the minerals and fossils, by Professor J. W Bailey, page 547. See note [pp. 117, 118] of the present report.

† Exploration of the Valley of the Great Salt Lake, by Captain Howard Stansbury, 1852. Appendix, geology and palæontology, by James Hall; page 402.

‡ See Pacific Railroad Reports; survey of the thirty-second parallel; Chapter IX, page 102.

know, of all the other species of the lowest and upper two Nebraska Cretaceous formations in the rocks from which Roemer and others collected so many species in Texas, and other southwestern localities, renders it highly probable that if the latter occur at all in Nebraska, they must be represented by the beds Nos. 2 and 3 of our section. This conclusion is further strengthened by the fact that the only Nebraska species yet found in the southwest, so far as we know, are *Inoceramus problematicus* and *Ostrea congesta*, both of which are unknown in the northwest, excepting in the above named beds, and are mainly restricted to the latter. The well marked specific characters of these two fossils and their limited vertical range, together with their extensive geographical distribution, render the bed in which they occur a horizon as the highest importance in the identification of strata at remotely separated localities in these far western Territories.

"That these beds, or formations of the same age, are widely distributed over a vast area of country, extending from near the great bend of the Missouri, in latitude 44° 15′, longitude 99° 20′, westward to, and perhaps beyond, the eastern slope of the Rocky Mountains, and far south into Texas and New Mexico, is highly probable, from the occurrence of their characteristic fossils at many widely separated localities in this region. At any rate we know, from information obtained through Mr. Henry Pratten, of the geological survey of Illinois, that *Inoceramus problematicus* is found in a light-colored limestone overlying a red sandstone on Little Blue river, a tributary of Kansas river. Colonel Frémont also collected specimens of the same shell from a similar rock on Smoky Hill river, in latitude 39°, longitude 98°, and at other localities between there and the rocky mountains.* More recently Lieut. Abert found the same, or a closely allied species, at a point as far southwest as latitude 35° 3′ N., longitude 107° 2′ W., and apparently on the western declivity of the anticlinal axis of the Rocky Mountains.† Roemer likewise collected in Texas specimens of a shell he refers to *Inoceramus mytiloides* of Mantell, which is considered identical with *I. problematicus* of Schlotheim. In addition to this we have seen, in Mr. Marcou's collection, specimens of *Ostrea congesta*, from Galisteo, between Fort Smith and Santa Fé, where it probably holds the same geological position as the so-called *Gryphæa dilatata.*

"The formations from which the above named fossils were obtained in the southwestern Territories, appear, from the statements of the various explorers of that region, to repose on a series of red, yellow, and whitish sandstones, and various colored clays, which are referred by Mr. Marcou to the Jurassic and Triassic systems. These lower beds, we think, are represented wholly or in part in Nebraska, by our formation No. 1, which, as previously stated, we regard as probably belonging to the lower part of the Cretaceous system, though it may be older."

Finally, in reference to the relative position in the series of a large part of the cretaceous fossils of the Boundary Survey, I have already, in a previous communication, stated that I regard them as occurring in the same geological horizon with the beds of Smoky Hill river, Poblazon, &c. I am now prepared to fix their position in the same parallel with beds Nos. 2 and 3 of the Nebraska section, and below those beds in New Jersey and Alabama, which contain *Baculites ovatus*, *Nautilus De Kayi*, and *Ammonites placenta.*

The reasons for this conclusion are obvious from what has preceded. The most conspicuous known fossils of beds 2 and 3 in Nebraska, are found in Arkansas and elsewhere, associated

* See Prof. Hall's figures and remarks in Frémont's report, p. 174, pl. 4.

† Lieut. Abert's report of explorations in New Mexico and California, p. 547.

with many of the species of the Boundary Survey collections, and from the persistence of *Inoceramus problematicus*, and the almost uniform character of the rock in which it occurs, from Nebraska to New Mexico, we can have no doubt that the beds containing this fossil everywhere occupy the same horizon.

The collections from the southwest have never furnished specimens of the cephalopods enumerated above, which characterize the upper cretaceous strata, and the few fossils which are common to Texas and New Mexico and New Jersey, render it probable that the higher beds of the formation have thinned out in that direction to a degree which renders them subordinate in importance to the lower beds of the system. The few specimens identical with species known in New Jersey, Alabama, and Tennessee, appear, from their color and the character of the associated rock, to have been obtained in a different bed from that of the greater number of specimens in the collection, which are associated with a more calcareous rock. At the same time, the absence of sections of strata leaves us without positive information in this respect.*

In the present state of our knowledge, it would appear that the beds 2 and 3 of the cretaceous formation of Nebraska have gradually increased in thickness and importance in a southwesterly direction, and, at the same time, have become more fossiliferous. In tracing the same beds through Arkansas, we find, in addition to the *Inoceramus problematicus*, and associated with that fossil, *Holectypus planatus*, *Toxaster elegans*, *Holaster simplex*, *Cardium multistriatum*, *Inoceramus confertim-annulatus*, *Gryphæa Pitcheri*, and others, which occur also among the Boundary collections. These facts clearly show that the beds have become much more fossiliferous than on the Missouri, or on the Kansas and Blue rivers, and we must regard the greater part of the Boundary collections as derived from the horizon of these beds.

From the great vertical range of the characteristic cephalopods, above enumerated, in New Jersey, and their wide geographical distribution, and from the marked distinction in the types of fossils holding the lower position, we shall probably find it convenient to subdivide the cretaceous formation into three great groups:

3. The upper division, comprising the first and second marl beds of New Jersey, with the intermediate ferruginous sand, and the clay below the first greensand bed, (Nos. III to VI of the section,) parallel to the beds 4 and 5 of Nebraska.

2. The middle division, equivalent to the beds 2 and 3 of Nebraska, and the calcareous beds of the southwest, Arkansas, Texas, and New Mexico, containing the numerous *Echinoderms*, *Inoceramus problematicus*, *Gryphæa Pitcheri*, *Hippurites*, *Caprina*, *Nerinea*, *Ammonites Texanus*, and numerous other fossils.

1. The lower division, represented by No. 1 of Nebraska, and probably equivalent to the lower clay beds of New Jersey, in which the only fossils yet known are of vegetable origin.

It is not unlikely that the medial division may prove, in many localities, to be divisible into distinct beds beyond those recognized in Nebraska; or, that as the formation expands to the southward, other beds not known on the Missouri will come in, or that the two there known will be found to become much modified in character.

* A single observation in the notes accompanying the specimens leads me to infer that *Exogyra costata*, and one or two species besides, were collected from a higher position in the cliff than the other fossils. Since, however, it is probable that many species, not known in the same association in New Jersey and Alabama, may occur in connexion with *Exogyra costata* in the southwest, we cannot at this time separate the species belonging to the upper and lower divisions of the formation.

I learn, also, from Dr. Parry, since these pages were written, that he regards the bed containing *Exogyra costata* and some other species, as holding a higher position than the calcareous beds of Leon Springs, and other localities along the route.

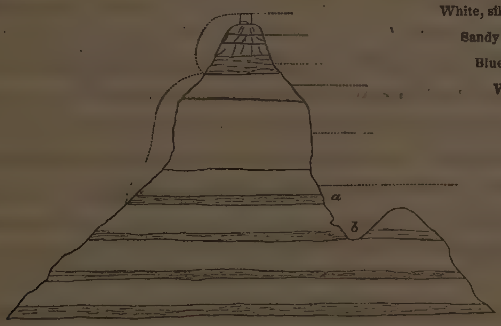
From the facts before us it appears that Nos. 4 and 5 of the upper division, which are so largely developed on the upper Missouri, become gradually attenuated towards the southwest, and lose in a great measure their distinctive fossils.

Although the specimens in the boundary collections do not clearly indicate the occurrence in that region of the sandstone No. 1 of the Nebraska section, it is nevertheless quite certain, from other collections in my possession, that the same rock occurs on the Arkansas river, possessing the same characters as in Nebraska.

Dr. Shumard, in his examinations in Arkansas, speaks of a sandstone which clearly holds the place of No. 1 of our section. On page 181 of report, before cited, he says: "Passing this range, the sandstone again reappears, and constitutes the prevailing rock to within a short distance of Fort Washita, where it disappears, and is succeeded by strata of the cretaceous period." Although not recognized by Dr. Shumard as a member of the cretaceous formation, still it holds, in regard to the beds in Arkansas, equivalent to Nos. 2 and 3 of Nebraska, the same relative position as the sandstone No. 1 on the Missouri river.*

The observations made in the course of the boundary survey, and in all the other surveys in the southwest, show the occurrence of various colored sandstones and clays below the fossiliferous beds identified, as above, with Nos. 2 and 3 of the Nebraska section. Indeed, we have evidence, from numerous observations, of the occurrence of a similar sandstone at so many points from Missouri to New Mexico as to render it certain that the formation is continuous over this wide extent of country.

The observations of Mr. Marcou, on the line traversed by one of the Pacific railroad surveys, induced him to regard these sandstone as of older date than the cretaceous formation. In a section of Pyramid Mountain given by Mr. Marcou, (*Bulleten Soc. Geol. de France, tome* 12, *p.* 878,) he recognizes a series of sandstones and clays beneath limestones which are of unquestionable cretaceous age.



"*a.* Bed of variegated marls in contact with the Jurassic formation."
"*b.* Alternations of calcareo-argillaceous marls of variegated colors—red, green, and white."
"*c.* Bed of *Gryphæa dilatata* and of *Ostrea Marshii.*"†

* I believe that Dr. B. F. Shumard regards this sandstone, in part, or altogether, as of carboniferous age; but it is difficult to understand these relative positions, since in numerous localities, from the Missouri river to Texas, the upper carboniferous limestone is the highest determined carboniferous rock, and underlies the sandstone No. 1 of the Nebraska section.

† These explanations of the section quoted above are those given by Mr. Marcou. The designations at the right hand are those given by him in the text accompanying the section.

Having examined the specimens in Mr. Marcou's collection from this locality, I have no hesitation in saying that the specimens labelled by him as *Gryphæa Tucumcarii* (*G. dilatata*, var. *Tucumcarii*, *Bul. Soc. Geol. de France*, *tome* 12, *pl.* 21) are the *Gryphæa Pitcheri* of Morton, and present no features, either in form, characters, condition of preservation, or otherwise, which can serve to distinguish them from *Gryphæa Pitcheri*, in the boundary survey collections, from strata forming a continuation of the Llano Estacado.*

In the section of Pyramid Mountain given by Mr. Marcou, the exhibition of the sandstones and clays beneath the limestone, with *Gryphæa Pitcheri*, is extremely interesting, as giving the succession of beds, with lithological character, more in detail than has elsewhere been published from that region.

For the purpose of comparison, I subjoin some detailed sections made by Mr. Meek, in 1853, upon the upper Missouri, and which are collectively merged in the sandstone No. 1 of our section of the cretaceous formations, as already given.

Section at the mouth of Big Sioux river.

Partially indurated, silicious clay, or marl, of a slightly yellow color, and showing scarcely any lines of stratification. Slope of 60 feet of modern or bluff formation.

Part of No. 1, section of Nebraska cretaceous formation.

1. Soft, yellow sandstone, with vertical veins and joints filled with silicious oxide of iron; also, hard, horizontal seams, containing much iron, with casts of *Pectunculus Siouxensis:* 10 feet.

2. Large, concretionary masses, 8 to 10 feet long, and 6 feet thick, consisting of hard, fine-grained sandstone, with perhaps some calcareous matter, laminated on the weathered surfaces: 6 feet.

3. Soft sandstone, like that above, with horizontally arranged concretions of siliceous oxide of iron, which are often hollow.

The three lower divisions of sandstone constitute the upper part of No. 1 of the Nebraska section. They were not seen in actual contact with beds of No. 2; but, from their position and dip relative to the other beds, there can be no doubt of the relations of the two. Subsequently, Dr. Hayden has seen the beds of Nos. 1 and 2 in actual contact on the Big Sioux river.

At a point twenty-five miles below Sergeant's Bluff there is an exposure of about 100 feet, consisting of beds of sandstone and clay, which present great irregularity in bedding, some of the strata rapidly expanding in one direction, while others thin out in the opposite direction.

Section on the right-hand side of the Missouri river, twenty-five miles below Sergeant's Bluff.—Successive beds, or strata, forming part of No. 1, Nebraska section of cretaceous formation.

1. A bed of dark-gray clay, alternating above and below with soft sandstone seams. The middle mostly clay; 6 feet.

2. Light, yellow clay, passing downwards into a very soft, gray sandstone; 5 feet.

3. Very dark clay, with fragments of carbonized wood; 1½ feet.

* The specimens from Pyramid Mountain are figured in the Report of the survey of the 35th parallel, and those of the boundary survey will be found in the present volume.

4. Gray, indurated clay, or marl, with pieces of carbonized wood; 4 feet.

5. Dark seam, like No. 3; 8 inches.

6. Clay, like No. 4; 3 feet.

7. Gray sandstone, with fragments of carbonized wood; 2 feet.

8. Very dark gray clay, sometimes black, and containing much organic matter in the lower part, crystals of selenite, etc.; 10 feet.

9. Gray clay, with many fragments of carbonized wood; harder concretions of the same clay, containing carbonized wood; 30 feet.

10. Gray sandstone, with pieces of carbonized wood; 2 feet.

11. Gray clay, with thin, wedge-shaped masses of hard bituminous coal, or lignite, and round lumps of sulphuret of iron.

Slope to river-level 30 or 40 feet, in which no beds, in place, were seen.

Many of the beds noted in the above section are seen to thin out entirely, or wholly to change their character in the same bluff within a distance of not more than fifty yards; while others, so thin and obscure as to attract no attention, are seen to increase to a much greater thickness in a very short space; while about two hundred yards below where the above section was made, the same line of bluff passes wholly into a soft, heavy-bedded sandstone, which breaks into large, columnar masses from the top to the base of the cliff.

The following sketch gives an example of the irregularity of the stratification in these bluffs of sandstone and clay:

a. Soft, heavy-bedded, yellow sandstone, with pieces of carbonized wood.
b. Dark, almost black, slaty clay, with much carbonized matter.
c. Gray sandstone, with specks of carbonized wood.
d. Hard, reddish sandstone.
e. Indurated gray clay, weathering to a light reddish hue.
f. Sandstone like the upper bed.

These are exhibitions of isolated exposures of the sandstone, clay, etc., constituting No. 1 of the Nebraska section, and which, from its relative position to certain fossiliferous beds, underlies the calcareous strata containing *Gryphæa Pitcheri*, and its associated fossils. This sandstone (No. 1) will include, at least, all that portion of the Pyramid mountain on the left hand side, marked in the diagram 1, while the blue clay, sandy limestone, and white, silicious limestone, represent, as we believe, the beds Nos. 2 and 3 of Nebraska; and this inference is deduced from the facts already stated, that these calcareous beds of the Llano do elsewhere contain the association of fossils characteristic of the horizon of Nos. 2 and 3, which we clearly

trace from Nebraska to New Mexico, and which are likewise, over a large part, or the whole distance, underlaid by sandstones, etc.

With regard to the two hundred feet of sandstones and clays below *a* of the Pyramid mountain, these may be a distinct formation, or they may be a part of the same formation as the beds above. Of all the collections yet examined from the southwest, not a single fossil from beds below those containing *Gryphæa Pitcheri*, and its associated fossils, has come under my notice. We are, therefore, without the means of identification at the present time.

The sandstones of the northwest have a great development, and it is not probable that we yet know their full thickness or their relations throughout. The collections made by Dr. Hayden, at the mouth of the Judith river,* contain a single genus, *Hettangia*, which, in Europe, is considered as restricted to the Liassic epoch. This, however, is associated with cretaceous types, and though there is some evidence in favor of a reference to the Jurassic period, we have not satisfactory proof.

The results at which we have arrived in regard to the identity of the western and southwestern cretaceous formations, may be more clearly appreciated by a comparison of sections of the upper Missouri and of the same formations on the line of the Boundary Survey.

Section of the Llano Estacado and the prolongation of the same beds to the southwest.

4. Tertiary sandstone, conglomerates, etc., with clays and impure limestones.

3. Dark colored, argillaceous limestone, frequently composed largely of broken shells, and containing *Exogyra costata.*

2. Yellow, or buff colored limestone, arenaceous limestone, clays, etc., with *Inoceramus problematicus, Gryphæa Pitcheri, Ammonites Texanus, Toxaster Texanum, Pyrina Parryi*, etc.

1. Sandstones and clays of a white, gray, or red color, containing few or no fossils.

Section of the beds seen on the Missouri river from Dixon's Bluff to Fort Pierre, and thence to Mauvaises Terres.

4. Tertiary sandstones, conglomerates, argillaceous limestone, clay, etc.

3. Light colored calcareous clay, and dark colored astringent clay, with nodules of limestone.

2. Gray or buff colored, and blue or lead colored argillaceous limestone, clay, etc., containing *Inoceramus problematicus, Ammonites*, etc.

1. Sandstones and clay, white, gray, or brown, in irregular and unequal alternating beds, containing few fossils beyond fragments of carbonized wood.

I can, therefore, only regard the sandstone of the southwest, or at least a large part of it, as identical in age and a prolongation of the formation No. 1 of Nebraska, and which, from the evidence of its cretaceous character and the absence of any evidence to the contrary, I refer to the cretaceous period.

* The formation at the mouth of the Judith river, containing a group of fossils quite distinct from any heretofore described, has been referred by Messrs. Meek and Hayden, provisionally, to No. 1 of the Nebraska section, from its general lithological analogy, and from position; but at that point the beds 2 and 3 are wanting, these fossiliferous beds lying immediately below No. 4 of the section.

REMARKS UPON THE TERTIARY FORMATION.

In addition to the Eocene marine tertiary fossils of the Boundary collections, there are numerous specimens of regularly stratified sandstone, conglomerate, clay, etc., which are referrible to the tertiary period. The relations of the beds of these different series and their great thickness indicate that they belong to a system of deposits having a wide extent in that part of the country from which the specimens were derived. The mineral aspect of the specimens, the association of clays, sandstones, and conglomerates, show a close similarity with the tertiary formation of the Mauvaises Terres of Nebraska. Further explorations, collections, and comparisons are certainly necessary before this identity can be fully established; but the numerous intermediate explorations, from the Missouri river to the Mexican boundary line, indicate the occurrence of similar formations along the entire distance. The collections from the tertiary basin east of the Cordilleras likewise present specimens of lithological aspect and conditions so similar to those of the Rio Grande on the east, that there would appear to be some relation between the formations at these distant points.

The tertiary materials in the collections do not appear to me sufficient to furnish more than grounds for a probable inference regarding the identity of the formations, and in the almost entire absence of fossils from the western basin, it might be unwise to express any positive opinion regarding the equivalency of these beds.

Without possessing the means of a detailed section of the successive beds along the line of the boundary survey, we are able, from the specimens of rocks and fossils in the collection, to present the order of succession and general features of the formations and their relative position.

The following section will serve to show the order of succession and relative age of the formations crossed by the Boundary survey:

TERTIARY FORMATION.

Tertiary formations on the west coast, probably of Miocene age.

Tertiary formations east of the Cordilleras, consisting of beds of sandstone, sand,* conglomerates, etc., with subordinate beds of sandstone. Formations in the valley of the Rio Grande, consisting of sandstone and conglomerate, with their calcareous beds, resembling in many respects the tertiary formations of the Mauvaises Terres in Nebraska.

Calcareous beds, with marine fossils of the Eocene tertiary, apparently underlying unconformably the preceding strata.

CRETACEOUS FORMATION.

Argillaceous beds, containing *Exogyra costata*, etc.

Calcareous beds of a buff color, and similar beds of a lead color, with beds of white limestone, containing *Gryphæa Pitcheri*, *Cardium multistriatum*, *Toxaster*, *Holectypus*, *Cyphosoma*, *Pyrina*, *Ammonites Texanus*, *Hippurites*, *Caprina*, *Nerinea*, etc.

Sandstone of various colors, white, brown, red, etc., with beds of clay, etc.

CARBONIFEROUS FORMATION.

Upper carboniferous limestone, containing *Spirifer cameratus*, *S. lineatus*, *Terebratula subtilita*, and other fossils of the age of the coal measures. Perhaps, also, some other members of the coal measures, represented in the altered sandstones and slates of the collection.

* The drifting sands of the southwest, like those of the north, appear to be derived from the sandstones of the tertiary period

DEVONIAN AND SILURIAN FORMATIONS.

The specimens referrible to strata of this age are few, and these are in such condition as to give little satisfactory information regarding the rocks in place.

NEWER IGNEOUS AND METAMORPHIC ROCKS.

Igneous and metamorphic rocks of the Limpia, Guadaloupe, and Organ mountains, Sierra Madre, etc., which are of modern origin.*

OLDER METAMORPHIC ROCKS.

Metamorphic rocks of Silurian and Devonian age, forming the range of the Cordilleras and the isolated mountains in the great plain on the east of that mountain chain.

* The materials which appear as the result of igneous and metamorphic action, may be derived from rocks of the coal measures and from older formations, as well as from those of more recent date. But from all we know of the character of metamorphic, silurian, devonian, and carboniferous strata elsewhere, those here referred to do not possess the same characters and do not belong to the same period of metamorphism.

DESCRIPTIONS OF CRETACEOUS AND TERTIARY FOSSILS.

BY T. A. CONRAD.

The organic remains in the collection of the Boundary Survey are chiefly cretaceous shells, which I have carefully compared with the Alabama and New Jersey species; and out of more than one hundred species in Roemer's and the Survey collections, I can find only two that may be considered identical with New Jersey species. These are *Exogyra costata* and the *Ostrea vesicularis* of Lam., which is at least a marked variety, termed *ancella* by Roemer. D'Orbigny places some of Roemer's Texan species in the same division to which he refers all the New Jersey species, the Senonian stage; yet I think there is sufficient evidence that the cretaceous strata of Texas are not exactly synchronous with those of New Jersey, or of Alabama, while those of the latter State appear to form a passage or intermediate stage between the cretaceous strata of the two former states, which, besides the *Exogyra* and *Ostrea* above mentioned, have four other species in common, viz: *Gryphæa Pitcheri*, *Trigonia thoracica*, Morton, *Baculites anceps*, and *B. asper*.

Among these interesting fossils, those from Leon Springs are conspicuous for variety and beauty, and unequivocally mark the cretaceous period. There is not the slightest trace of the Jurassic or any formation older than the grand epoch of the chalk. A few interesting fossils from near the mouth of Puercos river are imbedded in a white, chalky limestone, and, with the exception of *Ammonites Texanus*, are peculiar to this locality, in the present state of our collections. There is a specimen of flint from Leon Springs of the horn-shaped form so common in the chalk of Europe.

A few Eocene shells collected by Mr. Schott, of the age of the Claiborne formation, prove that Eocene strata occur in western Texas.

Eocene species.

Cardita planicosta, Arroyo Las Minas, between Eagle Pass and Leon.
Corbula nasuta, Con.
Cytherea Nuttalli, Con.
Cassidula alveata, Con.
Volutilithes Sayana, Con.
Natica limula, Con.

Cretaceous fossils from Oak Creek, Texas, collected by Arthur Schott.

Ammonites Texanus, Roemer, near Puercos river.
Nerinea Schotti, Con., near the mouth of Puercos river.
Caprina occidentalis, Con., near the mouth of Puercos river.
C. planata, Con., Oak creek, near Puercos river.
Hippurites? n. s., near the mouth of Puercos river.

Cretaceous fossils from between Rio San Pedro and Rio Puercos, collected by A. Schott.

Rostellaria? collina, Con.
R.? Texana, Con.
Natica collina, Con.
N. Texana, Con.
Buccinopsis Parryi, Con.

Cretaceous fossils from between El Paso and Frontera, collected by Colonel W. H. Emory.

Exogyra Matheroniana, D'Orbigny.
Gryphæa Pitcheri, Morton.
Cardium (Protocardia) Texanum, Con.
Trigonia Emoryi, Con.
Neithea Texana, (*Pecten*, Roemer.)
N. occidentalis, Con., (*quadricostata*, Roemer.)
Plicatula incongrua, Con.
Arca subelongata, Con.

Cretaceous fossils from Leon Springs, collected by Colonel W. H. Emory.

Exogyra Matheroniana, D'Orbigny.
E. arietina, Roemer.
E. læviusscula, Roemer.
Gryphæa Pitcheri, Morton.
Trigonia Texana, Con.
Lima Leonensis, Con.
Neithea filosa, Con.
N. Texana (*Pecten*, Roemer.)
N. occidentalis, Con.
Cardium multistriatum, Shumard.
Arcopagia Texana, Roemer.
Cardium Sancti-sabæ, Roemer.
Capsa Texana, Con.
Terebratula Choctawensis, Shumard.
Caprina crassifibra, Shumard.
Turritella Leonensis, Con.
Natica, ———.
Hamites larvatus, Con.
Ammonites flaccidicosta, Roemer.
A. Texanus, var. Roemer.
Cyphosoma Texanum, Roemer.
Pyrina Parryi, Hall.
Holectypus planatus, Roemer.
Toxaster Texanum.
Turbinolia Texana, Con.

Cretaceous fossils from Jacun, 3 miles below Laredo, collected by A. Schott.

Inoceramus Crispii, Mantell.
I. Texanus, Con.
Ostrea crenulimargo, Roemer.
Exogyra costata, Say.
Dosinea, (imperfect casts.)
Turritella (casts.)
Natica, (casts.)

Cretaceous fossils from Lepan Hills, collected by A. Schott.

Exogyra arietina, Roemer.
Terebratula Wacoensis, Roemer.
Neithea Texana (*Pecten*, Roemer.)
Cardium congestum, Con.
Ammonites Texanus, Roemer.
Hemiaster Texanus, Roemer.
Holectypus planatus, Roemer.

Of the above species *C. congestum* was collected on the Rio San Pedro, and all the others on the Rio Bravo del Norte.

Cretaceous? fossils from Dry Creek, Mexico, collected by A. Schott.

Ostrea cortex, Con.
O. multilirata, Con.

Cretaceous fossils from various localities, collected by A. Schott.

Neithea Texana (*Pecten* Roemer.) San Pedro River, mouth of painted caves; valley of the Rio Bravo, a few miles below the mouth of Rio San Pedro; upper valve of the same, near the mouth of the San Pedro.

Terebratula Wacoensis, Roemer, Aroyo Pedras Pintas.
Terebratula Wacoensis.—*Ibid.*
Inoceramus Crispii, Mant. Aroyo Pedras Pintas and Las Moras.
" " ? Salt Creek.
Neithea occidentalis, Con. Aroyo Las Minas, between Leon and Eagle Pass.
Ostrea carinata? Lam. Turkey Creek, Las Minas.
O. anomiæformis, Roemer, Turkey Creek, Las Minas.
Cardium congestum, Con. Valley of Royo San Felipe.
Ammonites flaccidicosta, Roemer, bed of Rio San Pedro.
A. Texanas, Roemer.
A. pedernalis, Roemer, Rio Bravo del Norte, near the mouth of Puercos river.
A pedernalis, Yellow stone.
Rostellites Texanus, Con. Eagle Pass.

POLYPI.

TURBINOLIA, Lam.

TURBINOLIA, TEXANA.

PLATE II, FIG. 3, *a*, *b*.

Horn-shaped, curved, with transverse, obtuse undulations; radii equal, prominent, numerous, (about 50 in number,) transverse section oval.

Locality.—Between El Paso and Frontera.

There are two specimens of this fossil in the collection, but the cup in each is filled with a portion of the limestone in which they were imbedded, and the characters are thus concealed.

ECHINODERMATA.

Several species of this family occur among the collections of the Boundary Survey. Three of these are identical with species described by Dr. F. Roemer, in his Kreidebildungen von Texas, while two others are quite distinct. Owing to the imperfection of the specimens in the collection, some of the figures have been copied from the work cited. It was not until the collections of the second survey of the Boundary were received that the *Toxaster elegans* was observed, and it has been figured on the supplementary plate 21. The association of these and other species with the well known cretaceous fossil *Gryphæa Pitcheri*, figured upon the same plate, leaves nothing further to be desired in proof of the age of the formation.*

PYRINA PARRYI, Hall.

PLATE I, FIG. 1, *a–d*.

Shell oblong ovoid, or somewhat pentagonal, with the angles rounded, convex above and concave in the middle beneath; apex central, flat or slightly depressed, prominently convex in front, and subtruncate behind; mouth central, oval; anus ovate, narrower above and situated centrally between the upper and lower side of the shell; ambulacral areas somewhat prominent or slightly elevated above the rest of the surface. Tubercles on the upper side scattered, with granular spaces between, becoming more numerous on the sides and crowded on the base of the shell. Length 1½ inches; width 1⅛ inches.

The general contour of the fossil is a broad oval, slightly narrower behind and subtruncate; while the elevation of the ambulacral space in front gives it a slight prominence in that part. This prominence of the ambulacral spaces likewise often gives an obtusely pentagonal form to the shell; but this character is not constant, nor is the slight prominence in front observable in all specimens.

This neat and pretty species is readily distinguishable from any other yet described from the cretaceous rocks of the southwest.

* Prof. Agassiz, to whom these fossils were submitted, expressed his opinion that they were from the lower cretaceous formation.

Fig. 1*a*. Upper side of specimen.
Fig. 1*b*. Lower side.
Fig. 1*c*. Posterior view.
Fig. 1*d*. Portion of the summit enlarged.
Locality.—Leon Springs, El Paso road.

TOXASTER TEXANUS.

PLATE I, FIG. 2, *a–c*.

Toxaster Texanus, Roemer, Kreidebildungen von Texas; p. 85, pl. x, fig. 3.

Shell oblong, subpentagonal-ovate, rotund before, the middle emarginate, truncate behind, elevated convex; mouth transverse, subreniform; anal aperture round-oval; the larger tubercles arranged in a triangular area upon the lower surface.

The specimens of this species in the collection are somewhat compressed vertically, cordâte-ovate in form, rather abruptly emarginate in front.

Fig. 2*a*. View of the base of a specimen.
Fig. 2*b*. Upper side of the same.
Fig. 2*c*. Posterior view.
Locality.—Leon Springs, Texas.

CYPHOSOMA TEXANUM.

PLATE I, FIG. 3, *a–c*.

Diadema Texanum, F. Roemer, Texas; p. 392.
Cyphosoma Texanum, Roemer, Kreidebildungen von Texas; p. 82, pl. x, fig. 6.

Orbicular, scarcely subangular, little elevated, depressed above, plane or concave below; tubercles of the ambulacral and interambulacral areas equal, distinctly crenulate; tubercles of the ambulacral areas biserial, intermediate tubercles few; tubercles of the interambulacral areas arranged in two principal series, and two slightly smaller accessory series, intermediate tubercles numerous, scattered.

The specimens of this species in the Boundary collections are fragmentary.

Fig. 3*a*. Profile view.
Fig. 3*b*. View of lower side.
Fig. 3*c*. Enlargement of surface, showing the ambulacral and interambulacral tubercles, pores, etc.
Locality.—Leon Springs, Texas.

HOLECTYPUS PLANATUS.

PLATE I, FIG. 4, *a, b, c, d, e, f*.

Orbicular or subpentagonal, moderately elevated, extremely depressed conical; inferior surface plane, concave in the middle; ambulacral areas somewhat prominent above the rest of the surface; tubercles small above, larger below, vent ovate, very large, reaching from the mouth to the margin.

The specimens present some variety in the greater or less elevation of the apex; the base is often convex near the margin, becoming gradually depressed towards the centre. The tubercles are very minute above, giving a sense of roughness to the touch, becoming larger on the sides and much larger below. The upper surface is often nearly smooth, while the lower surface retains the tubercles strongly preserved.

Fig. 4*a*. Profile view.

Fig. 4*b*. Upper surface.

Fig. 4*c*. View of the base.

Fig. 4*e*. Ambulacral and interambulacral spaces enlarged.

Fig. 4*f*., *g*. Enlargement of a tubercle of base.

TOXASTER ELEGANS.

PLATE XXI, FIG. 1 *a–e*.

Hemiaster elegans, Shumard, in Marcy's report of Exploration of the Red River of Louisiana; page 210, pl. 2, fig 4 *a*, *b*, *c*.

Shell subcordate-ovate, much elevated, apex anteriorly sub-central, rotund before, and emarginate in the middle by a sinus which terminates below in the mouth; obtuse or subtruncate behind, with a shallow depression below the vent; mouth transverse, round-oval, with a shallow depression on each side extending to the margin, anus oval, near the upper margin; the larger tubercles scattered upon the upper surface, and becoming more numerous and larger on the sides and lower margin; a triangular lanceolate space beginning near the mouth, and widening to the posterior extremity, covered with large tubercles, with a space on each side entirely smooth, or with a few scattered tubercles.

This species has the ambulacral areas defined by broad, shallow grooves, which, with the exception of the anterior one, extend to the upper outer margin of the test. It resembles in many of its characters the specimens which have been identified as *Toxaster Texanum*, but the apex is more nearly central (being anterior to the centre, while in that one it is posterior.) In the specimens under consideration, the ambulacral spaces are all deeply impressed, and the antero-lateral ones are more divergent; the anus is nearer the upper edge, and its greatest length is in a vertical direction. Although the figures of Dr. Shumard convey no very definite idea of the characters, yet his description is very satisfactory, and leaves little doubt regarding the identity of that species with the one under examination.

Fig. 1*a*. Upper side.

Fig. 1*b*. Lower side.

Fig. 1*c*. Profile of posterior end.

Fig. 1*d*. Lateral view in outline.

Fig. 1*e*. Enlargment of the surface.

Locality.—Eagle Spring, Texas.

BIVALVES.

CAPRINA, D'Orbigny.

CAPRINA OCCIDENTALIS.

PLATE II, FIGURE 1, *a*, *b*, *c*.

Caprina occidentalis, Con. Proc. Acad. Nat. Sci. vol. VII, p. 268.

Falcate, flattened on the side of the outer curve, convex on the opposite, the other margins acutely rounded; surface very obscurely striated transversely, substance coarsely fibrous.

Locality.—Near the mouth of Puercos river.

CAPRINA PLANATA.

PLATE II, FIGURE 2, *a*, *b*.

Caprina planata, Con. Proc. Acad. Nat. Sci. Vol. VII, p. 268.

Flattened on one side and convex on the opposite, much compressed, very long and narrow, falcate, fibrous, and exhibiting small septa.

A fragment of a valve, two feet in length, and another smaller fragment, are all of this species that I have seen. The cavities between the septa are lined with crystals of carbonate of lime, and both this and the preceding species are imbedded in white friable limestone.

Locality.—Oak creek, near Puercos.

TEREBRATULA, Lhwyd. Lam.

TEREBRATULA WACOENSIS.

PLATE III, FIGURE 1.

Terebratula Wacoensis, Roemer, Kreide. von Texas, p. 81, pl. VI.

Inflated, semi-globose, pentagonal, smooth; front margin straight, not inflated, dorsal valve most convex; umbo obtuse, slightly incurved; area sufficiently distinct, circumscribed by an obtuse angle; ventral valve suborbicular, regularly convex; surface minutely punctate.

Locality.—

TEREBRATULA CHOCTAWENSIS.

Terebratula Choctawensis, Shumard, Geol. of Red river, p. 207, pl. II, fig. 3.

Suboval, truncated at base; both valves ventricose, surface elegantly marked with minute punctæ.

Locality.—Leon Springs.

TRIGONIA, Lam.

This interesting genus has been found as far down in the geological series as the triassic rocks. D'Orbigny enumerates ninety-nine species, and although there is one living representative on the coast of Australia yet the genus is unknown in the strata of tertiary periods.

TRIGONIA EMORYI.

PLATE III, FIGURE 2, *a*, *b*, *c*.

Trigonia Emoryi, Con. Proc. Acad. Nat. Sci., vol.

Inequilateral, obliquely truncated posteriorly, alated; obliquely ribbed; ribs about 34, narrow, prominent, compressed, or laterally abrupt, nodulose, diverging near the dorsal margin; ribs posteriorly, about the umbonal slope, composed of series of small nodules.

The form of this species approaches nearest to *T. crenulata*, but it is wider across the middle between the buccal and umbonal slope. The form of ribs is most nearly like those of *T. scabra*, but that shell has a wider anal area, and the dorsal depression is much smaller, being of a more ovate cuneate form.

Locality.—Between El Paso and Frontera.

TRIGONIA TEXANA.

PLATE III, FIGURE 3, *a*, *b*, *c*.

Trigonal cast of a large species, which is profoundly ventricose, truncated and direct on the ventral end, summits profoundly elevated; shell unknown.

Locality.—Leon Springs.

MACTRA, Lin. Lam.

MACTRA TEXANA.

PLATE IV, FIGURE 1, *a*, *b*.

Mactra Texana, Con. Proc. Acad. Nat. Sci., vol. VII, p. 269.

Triangular, ventricose, subequilateral, buccal end subangulated and slightly produced, much above the line of the base, which is regularly and profoundly curved, anal margin obliquely truncated, extremity angulated; buccal margin straight and very oblique; summit prominent.

This species is known from casts, and may prove to belong to the genus *Schizodesma*, Gray.

Locality.—Prairie between Laredo and Rio Grande city.

CUCULLÆA, Lam.

CUCULLÆA TERMINALIS.

PLATE IV, FIGURE 2, *a*, *b*.

Ovate-triangular, ventricose; buccal margin in the cast almost direct; anal side produced, cuneiform, extremity angulated; basal margin straight; summit profoundly prominent.

I have not seen the shell of this species. Comparing the casts with those of *C. vulgaris*, Morton, the summits are found to be much more prominent and more distant, as well as more nearly terminal.

Locality.—

ARCA, Lin.

ARCA SUBELONGATA.

PLATE VI, FIGURE 3, *a*, *b*.

Trapezoidal; anterior end regularly and rather acutely rounded; hinge and basal margins parallel· posterior extremity obliquely truncated.

Locality.—Between El Paso and Frontera.

ARCOPAGIA.

ARCOPAGIA TEXANA.

Plate IV, Figure 3, *a*, *b*.

Arcopagia Texana, Roemer, Kreide. von Texas, pl. VI, fig. 8.

Orbicular, compressed, lentiform, inequivalve, subtortuous, cardinal margin nearly straight, forming an obtuse angle with the posterior margin; anterior muscular impression distinct, elongated, linguiform; posterior impression subrotund, approaching the cardinal margin; umbo small and slightly prominent.

CARDIUM, Lin. Lam.

CARDIUM MEDIALE.

Plate IV, Figure 4, *a*, *b*.

Cordate, equilateral, ventricose; base profoundly and nearly regularly rounded; beaks prominent; posterior margin truncated, direct.

Locality.—

CARDIUM CONGESTUM.

Plate VI, Figure 5, *a*, *b*, *c*, *d*.

Cordate, inflated, subequilateral; umbo prominent; beaks approximate; ribs radiating, probably about twenty-five in number.

An abundant species in the form of casts of entire specimens. A mere trace of the shell in one of these leads to the inference that the ribs were carinated. It has some general resemblance to *C. constantia*, D'Orbigny, but, unlike that species, it is oblique.

Locality.—Rio San Pedro.

CARDIUM, Sub-genus PROTOCARDIA, Beyrich.

The genus *Protocardia* of Beyrich was founded on the *Cardium Hillanum* of Sowerby. A number of species have been figured by authors—four have been described in D'Orbigny's Palæontologie Française. They are generally indicated by concentric lines or ribs, and have radiating striæ only on the post-umbonal area. The hinge resembles that of the Linnæan Cardium, and the species seem to pass into that genus, even through external characters. Nevertheless, they form a natural section, having no living representative, and characterizing the cretaceous and older tertiary formations.

CARDIUM (PROTOCARDIA) MULTISTRIATUM.

Plate VI, Figure 4, *a*, *b*, *c*.

Cardium multistriatum, Shumard. Geol. of Red River, p. 207, pl. IV, fig. 2.

Subrotund, inflated, height and length nearly equal; truncated posteriorly; basal and anterior margins rounded; surface of posterior submargin, with 14–15 regular radiating striæ; remainder of surface marked with fine, equal, rounded, close concentric striæ; summit rather prominent.

Locality.—Leon Springs.

CARDIUM (PROTOCARDIA) TEXANUM.

PLATE VI, FIGURE 6, *a*, *b*, *c*.

Cardium Hillanum, Roemer, (not Sowerby,) Kreide. von Texas, p. 39, pl. VI, fig. 12.

Cordate, subquadrate, obliquely truncated posteriorly; umbo slightly oblique, submedial; disk concentrically ribbed; ribs large and prominent, rounded, laterally abrupt, fine and close on the umbo; post-umbonal area with about 17 tuberculated radiating lines.

Locality.—Between El Paso and Frontera.

CARDIUM (PROTOCARDIA) FILOSUM.

PLATE VI, FIGURE 7, *a*, *b*.

Triangular, elevated, with numerous minute, concentric lines anterior to the umbonal slope, which is obtusely carinated; umbonal and post-umbonal slopes marked with close, fine radii, about 30 in number.

This is the smallest species I have seen, and the only one with a carinated umbonal slope.

Locality.—Leon Springs.

CARDITA, Lam. Blainville.

CARDITA EMINULA.

PLATE VI, FIGURE 8.

Ovate-acute from beak to base, elevated; ribs 16, prominent, rounded? Those on the anterior slope angular, acute, umbo narrow, beaks pointed and elevated.

There is one specimen of this—a cast of both valves; there appear to be traces of radiating lines between the ribs.

Locality.—Leon Springs.

CORBULA.

CORBULA OCCIDENTALIS.

PLATE VI, FIGURE 9.

Allied to *C. oniscus*, Con.; but has finer and more numerous concentric furrows. It is probably an Eocene species; but was found in western Texas.

NEITHEA, Drouet.

This genus, it appears to me, should be restricted to that group of shells with an angular base of which *Pecten quinquecostatus*, Sowerby, is the type. So restricted, the genus is probably confined to the Cretaceous strata, and is certainly highly characteristic. No species of it occurs in Tertiary formations, nor in a living state.

NEITHEA OCCIDENTALIS.

PLATE V, FIGURE 1, *a*, *b*.

Neithea occidentalis. Conrad. Proc. Acad. Nat. Sci. vol. VII, p. 269.

Pecten quadricostatus, Roemer, (not Sowerby,) Kreide. von Texas, p. 64, pl. VIII, fig. 4.

Ovate-triangular; lower valve inflated, unequally ribbed, and concentrically striated, lines very fine; large ribs rounded and elevated, smaller ribs equal, two in number in each of the

intervals of the larger ribs, which latter have on each side a raised line or fine rib, giving it a trifid character; upper valve subconcave.

This species differs from *P. quadricostatus*, Sowerby, in having but two equal ribs between the larger, while that species his three corresponding ribs, and it is also proportionally a narrower or more elevated shell.

NEITHEA TEXANA.

PLATE V, FIGURE 2, *a*, *b*.

Pecten Texanus, Roemer, Kreide. von Texas, p. 65, pl. VIII, fig. 3.

Orbiculate-triangular, plano-convex; inferior valve convex, with 15–17 ribs, which are subequal, broad, flattened, smooth, and bisulcate laterally, or margined on each side by a small rib: superior valve flat; ribs unequal, slightly prominent, flattened.

Locality.—Between El Paso and Frontera.

LIMA.

LIMA WACOENSIS.

PLATE V, FIGURE 4, *a*, *b*.

Lima Wacoensis, Roemer, Kreide. von Texas, p. 63, pl. VIII, fig. 7.

Oblong-oblique, transverse, anteriorly subtruncated, with radiating ribs, which are slightly unequal, anteriorly narrower, closer, subdichotomous.

LIMA LEONENSIS.

PLATE V, FIGURE 3, *a*, *b*, *c*.

Very oblique, elevated, of a somewhat oblong-oval outline; buccal side produced, compressed, angular at the extremity; margin above the extremity truncated, very oblique; below it the margin is also truncated, and parallel with the umbonal slope; basal margin rounded; anal extremity angulated; ears small; ribs about 19 in number, angular or subangular, and carinated on the middle; surface with fine radiating lines, and towards the base the ribs are more distinctly carinated than above.

This is a larger species than the preceding, and differs in form, in having carinated ribs, and in having the summit of the right valve much more prominent or elevated than the left; the ears are also smaller, and the margin much below the summit of the right valve. The largest specimen measures rather more than 1½ inches from beak to anal extremity.

Locality.—Leon Springs.

INOCERAMUS, Sowerby.

INOCERAMUS CONFERTIM-ANNULATUS.

PLATE V, FIG. 5.

Inoceramus confertim-annulatus, Roemer, Kreide. von Texas, p. 59, pl. VII, fig. 4.

Transverse, oval, depressed, concentrically undulato-plicated and striated, folds robust, regularly rounded; intervals of the wider folds hardly equal; elevated lines very fine, equidistant, regular on the fold, and intervals.

Locality.—Near New Braunfels.

INOCERAMUS MYTILOPSIS.

PLATE V, FIG. 6, *a*, *b*.

Inoceramus mytiloides, Roemer, (not Mantell,) Kreide. von Texas, p. 60, Pl. VII, fig. 5.

Oblique, elongate-ovate, inflated, concentrically plicated and striated; umbo very oblique, summit acute, prominent; buccal side short, extremity obtusely rounded, and the margin above and below subtruncated, the latter parallel with the anal margin, which is oblique and subtruncated; anal side somewhat compressed.

This species is more oblique than *I. mytiloides*, with a longer cardinal line; is proportionally less elevated, with the margins subangulated, while in the *I. mytiloides*, they are regularly or obtusely rounded.

INOCERAMUS TEXANUS.

PLATE V, FIG. 7.

Elevated, suboval, compressed, equilateral; hinge, and lateral, and basal margins regularly rounded; folds robust, prominent, unequal; summit not prominent.

Locality.—Western Texas.

INOCERAMUS CRISPII.

PLATE V, FIG. 8.

Inoceramus Crispii, Mantell, Foss. of South Downs, p. 133, Pl. XXVII, fig. 11.

Equivalve, elongate-ovate, transverse, inflated, concentrically undulato-plicate, elegantly and finely striated; anal side subdepressed, produced; buccal side short, obliquely subtruncated; cardinal margin long and straight.

This appears to be the same species that Dr. Morton described as *I. Barabini*, but his specimens were very imperfect.

Localities.—San Antonio, Texas; Green county, Alabama.

PHOLADOMYA, Sowerby.

PHOLADOMYA TEXANA.

PLATE XIX, FIG. 3.

A fragment of a cast, with 13–14 distant, prominent, narrow, somewhat undulated or irregular ribs; intervening spaces concave; concentric lines coarse, but not very prominent.

Locality.—Turkey creek, Leon and Eagle Pass roads.

ASTARTE, Sowerby.

ASTARTE TEXANA.

PLATE V, FIG. 9.

Triangular, convex-depressed; buccal extremity subangulated, and much above the line of the base, which is regularly rounded. A cast representing both valves.

The locality is unknown to me; it is from western Texas.

CYTHEREA, Lam.

CYTHEREA LEONENSIS.

PLATE VI, FIG. 1.

Oblong-subovate, ventricose, very inequilateral; posterior margin, from beak to extremity, slightly sinuous; extremity truncated or obtusely rounded, direct.

Locality.—Leon Springs, El Paso road.

CYTHEREA TEXANA.

PLATE VI, FIG. 2.

Obliquely-ovate, ventricose, very inequilateral, with prominent lines of growth; umbo large; umbonal slope subangulated; buccal margin obtusely rounded; base profoundly rounded; dorsal margin straight, very oblique.

Locality.—Between El Paso and Frontera.

PLICATULA, Lam.

PLICATULA INCONGRUA.

PLATE VI, FIG. 10, *a*, *b*.

Ovate, small, lower valve ventricose, with prominent entire ribs bifurcating from the umbo; superior valve flattened, with squamose, scarcely prominent, ribs; interstices linear.

Fig. 10 *a* represents the flat squamose valve, and fig. 10 *b* the opposite smooth-ribbed valve, as they appear in relief on a piece of hard limestone.

EXOGYRA, Say.

This genus, which is related to *Gryphæa*, originated in the Oolitic epoch. It widely differs from *Ostrea*, though some authors, even at the present day, include the species in that genus. The fact that all the species died out before the oldest Tertiary period, favors the idea that the animal was somewhat differently organized from that of *Ostrea*.

EXOGYRA ARIETINA.

PLATE VII, FIG. 1, *a–e*.

Exogyra arietina, Roemer, Kreide. von Texas, p. 68, pl. VIII, fig. 10.

Exogyra arietina, var. *caprina*, Con. Jour. Acad. Nat. Sci., Vol. II, new series, p. 273.

Ventricose; larger valve having the umbo spiral, or shaped like a ram's horn; back with obtuse or obsolete angles and furrows, and undulated, subimbricated lines of growth; upper valve nearly flat, with concentric lamellose lines. Very abundant. The variety *caprina* is generally elegantly marked with distinct, prominent, radiating, interrupted, subnodulose ribs. On the weathered surface of the rock they project in great perfection, and are crowded in vast numbers. It is related to *E. Pellicoi*, Gervais.

Locality.—Leon Springs.

EXOGYRA FIMBRIATA.

PLATE VII, FIGURE 2, *a*, *b*.

Exogyra fimbriata, Conrad, Proc. Acad. Nat. Sci., vol. VII, p. 269.

Upper valve very thick, very convex, with 10 or 12 distant, concentric, prominent, imbricated laminæ; surface of valve covered with minute, semi-granular, interrupted, rugose lines; inner surface minutely subgranular interiorly; apex nearly terminal; lower valve unkown.

Locality—Western Texas.

EXOGYRA LÆVIUSCULA.

PLATE VII, FIGURE 4, *a*, *b*.

Exogyra læviuscula, Roemer, Kreid. von Texas, p. 70, pl. IX, fig. 3.

Ovate, gibbous; larger valve inflated, subhemispherical, obtusely carinated in the middle, smooth, irregularly ornamented towards the margin, with a few larger lines of increment; umbo distinctly spiral; interior margin of the valve suborbicular, thin.

Locality—Leon Springs.

EXOGYRA MATHERONIANA.

PLATE VIII, FIG. 1, *a*, *b*; and PLATE XI, FIG. 1, *a*, *b*.

Exogyra Matheroniana, D'Orbigny, Palæon. Fran., vol. III, p. 717, pl. 485, fig. 1.
Exogyra plicata, Goldfuss, (not Lam.)
Exogyra Texana, Roemer, Kreid. von Texas, p. 69, pl. X, fig. 1.
Exogyra Texana, Shumard, Palæon. of Red river, p. 205, pl. V, figs. 1 and 5.

Obliquely ovate, convex, thick; larger valve carinate-angulate; ribs radiating, unequal and granulate-nodose; umbo exhibiting a point of attachment; smaller valve granulose, with radiating ribs, often thickened; inner margin finely striated; muscular impression semi-circular or ovate, submedial.

Locality—Between El Paso and Frontera.

EXOGYRA COSTATA, var.

PLATE VIII, FIGURE 2.

Exogyra ponderosa, Roemer, Kreid. von Texas, p. 71, pl. IX, fig. 2.

Large, thick, ovate, inflated, concentrically lamellose-striate; larger valve gibbous, obtusely carinated, concentric, lamellæ, irregular, imbricated, laciniate towards the margin; umbo spiral, free; smaller valve thick, concentrically laminated, within smooth; umbo distinctly spiral, horizontal.

EXOGYRA COSTATA.

PLATE IX, FIG. 1 and 2; PLATE X, FIG. 1; and PLATE VIII, FIG. 3.

Exogyra costata, Say. Jour. Acad. Nat. Sci., vol. II, p. 43. Morton, Synopsis, p. 55, pl. VI, fig. 1 and 4.

Suboval, thick; lower valve convex, costated, concentrically corrugated; costæ somewhat

dichotomous, sometimes squamose; apex lateral, with about two volutions; muscular impression profound; upper valve with numerous elevated, concentric, squamose laminæ.

The Texan specimens agree in every respect with those of New Jersey and Alabama, and present the same varieties; some with, and others without, ribs, and every intermediate gradation.

Locality.—Jacun, three miles below Laredo.

EXOGYRA FRAGOSA.

PLATE VIII, FIGURE 2, *a*, *b*.

Exogyra fragosa, Con. Proc. Acad. Nat. Sci., vol. VII, p. 269.

Orbicular; lower valve ventricose posteriorly, flattened anteriorly; ribbed; ribs large and prominent, broad, irregular, some of them bifurcated, crossed by robust lamellar lines of growth; umbo small, flattened, very rough and strongly ribbed; inner margin rugosely striated; upper valve plano-convex, with a very uneven, subgranulated, rugose surface, and laminated towards the posterior and inferior margins; apex marginal.

A beautiful shell, differing from *E. ponderosa* or *costata* in having a much smaller umbo, wider ribs, and more rotund outline. The margins within are finely striated and anteriorly granulated. The upper valve is rugose-granulate interiorly. The figure does not well represent the elevation and inequality of the ribs.

Locality.—Between El Paso and Frontera.

GRYPHÆA, Lam.

GRYPHÆA PITCHERI.

PLATE VII, FIG. 3; and PLATE X, FIG. 2, *a*, *b*.

Gryphæa Pitcheri, Morton, Synopsis, p. 55, pl. XV, fig. 9.

Gryphæa dilatata, var. *Tucumcarii*, Marcou, Bul. de la Soc. Geol. de France, vol. XII, (May, 1855,) pl. XXI, fig. 3.

Ovate, gibbous, somewhat regular; inferior valve inflated, arcuate, lobed; lines of growth subimbricate; umbo large, prominent, subcompressed, incurved; smaller valve thick, with faint, impressed, radiating lines, compressed or laterally flattened above on the anterior side, slightly concave in the middle; surface concentrically imbricate-striate.

This widely-spread species occurs in all the localities in two distinct forms: one resembling *G. vesicularis*, and which is the type of the species as figured and described by Morton; and the other, truncated anteriorly, with a narrow, elongated, boat-shaped umbo, var. *navia*, pl. VII, fig. 3, *c*, *d*. The upper valve of the typical form is represented in pl. X, fig. 2, *a*, *b*. Roemer has given excellent figures of the var. *navia*.

Localities.—Leon Springs, Texas; plains of the Kiamesha, Arkansas; New Braunfels, Texas; Fort Washita and Cross Timbers, Texas.

OSTREA, Linn.

OSTREA SUBSPATULATA.

PLATE X, FIGURE 3, *a*, *b*.

Ostrea subspatulata, Lyell and Sowerby, Jour. Geol. Soc. London, vol. I, p. 61, (figured.)

Obovate; somewhat trapeziform, generally thick; higher than wide, narrower at the dorsal

than at the ventral or basal end, which is turned downwards at an obtuse angle; somewhat foliaceous externally; muscular impression placed very near the base.

This species approximates *O. Leymerii*, Desh. It was first discovered by Lyell in North Carolina, associated with *Belemnites mucronatus* and *Gryphæa vesicularis*. This group appears to represent the age of the *Gryphæa* and *Exogyra* beds of New Jersey.

Locality.—Western Texas.

OSTREA BELLA.

PLATE X, FIGURE 4, *a*, *b*.

Oblong-ovate, slightly curved; lower valve ventricose, undulated, with somewhat interrupted, radiating ribs, crossed by remote squamose concentric lines; beak produced; lesser valve flat, concave towards the base, marked by minute, obsolete, radiating lines.

Locality.—Western Texas.

OSTREA LUGUBRIS.

PLATE X, FIGURE 5.

Suboval; superior valve flat; inferior valve slightly ventricose, showing a mark of attachment on the umbo; ribs radiating, prominent, rugose, disappearing on the umbo. A small species, constant in character, and easily recognized.

Locality.—East of Red river, (Canadian,) New Mexico, Santa Fé road.

OSTREA CARINATA.

PLATE X, FIGURE 6.

Ostrea carinata, Lam. An. sans vert, Desh. ed. vol. VII, p. 240.
Ostrea carinata, Roemer; Kreid. von Texas, p. 75, pl. IX, fig. 5.

Subequivalve, elongated, arched, compressed, eared anteriorly, regularly plicated; folds equal, acute, carinated, diverging from a flattened surface on the back, geniculated at the angle and vertical on the sides, which are flattened.

I have not seen good specimens of this shell, and refer it to *carinata* chiefly on the authority of Roemer.

Localities.—Turkey creek, Las Minas; New Braunfels.

OSTREA VELLICATA.

PLATE XI, FIGURE 2, *a*, *b*.

Subovate, inferior valve convex, with very irregular, laminated, concentric lines, imbricated; surface as if pinched into cavities in places; beak subrostrated, thick; margins of the lower valve thickened, muscular impression comparatively near the base; hinge area broad.

I have seen but one valve of this species.

Locality.—Rio Grande, between El Paso and Frontera.

OSTREA ROBUSTA.

PLATE XI, FIGURE 3, *a*, *b*.

Elevated, subfalcate, thick; inferior valve convex; superior valve flattened, with rather distant subimbricated laminæ; apex truncated.

There are only two specimens of this species; the outer surface of the lower valve is abraded, and the characters obliterated; the upper valve in one is much thickened on the margins, which are crenulated within on the upper part.

Locality.—Jacun, three miles below Laredo.

OSTREA CORTEX.

PLATE XI, FIGURE 4, *a, d.*

Elongated, pointed towards the apex; inferior valve ventricose, very thick, with very prominent, concentric, imbricated laminae; cardinal fosset long and profound, somewhat curved, with a rounded ridge on each side.

A remarkable species, with a rough bark-like exterior; the upper valve is somewhat ventricose and marked like the opposite exteriorly.

Locality.—Dry creek, Mexico.

OSTREA MULTILIRATA.

PLATE XII, FIGURE 1, *a, d.*

Sub-triangular, thick and ponderous, somewhat curved; both valves flattened, irregularly undulated concentrically, and having numerous radiating, interrupted folds; umbo flat, very thick; cardinal fosset long and somewhat curved, deep, cavity very shallow.

This is a remarkable species, very variable in form. I know of no cretaceous species like this or the preceding, and as no other fossil was obtained with these, their geological age is uncertan; possibly they may belong to strata of earlier date than the cretaceous rocks of Texas.

Locality,—Dry creek, Mexico.

UNIVALVES.

NATICA, Lam.

NATICA TEXANA.

PLATE XIII, FIGURE 1, *a, b.*

Suboval; volutions, 5; rounded; spire prominent.

Locality.—Between Rio San Pedro and Rio Puercos.

NATICA COLLINA.

PLATE XIII, FIGURE 2, *a, b.*

This specimen may be the young of the former species. The cast is distorted and imperfect.

Locality.—Same as preceding.

ROSTELLARIA? Lam.

ROSTELLARIA? COLLINA.

PLATE XIII, FIGURE 3, *a, b.*

One or two imperfect casts of this fossil occur with the preceding *Natica.*

ROSTELLARIA? COLLINA.

PLATE XIII, FIGURE 4, *a*, *b*.

Elliptical; volutions, 6; those of the spire rounded; body volution, with a rather wide, slight, revolving depression near the suture.—(A cast.)

BUCCINOPSIS.

BUCCINOPSIS PARRYI.

PLATE XIII, FIGURE 4, *a*, *b*.

Sub-pyriform; longitudinally undulated and ornamented with rugose revolving lines; volutions flattened above; spire scalariform; aperture large and patulous.

Under this name I have described a cast which cannot be referred with accuracy to any known genus. The beak is broken and was probably produced.

Locality.—Same as preceding.

TURRITELLA, Lam.

TURRITELLA PLANILATERIS.

PLATE XIV, FIGURE 1, *a*, *b*.

Subulate; volutions with two large beaded revolving lines, and two smaller ones beneath, with an intermediate fine crenulated line; sides straight; the upper large revolving line gives the shell a carinated character.

Very distinct from *T. seriatum-granulatum*, Roemer. The shell and sculpture are in perfect preservation. It is accompanied by *Lima Leonensis*, a small *Natica*, and a small *Astarte*, which has about five broad concentric prominent ribs, and triangular in form. It may be named *Astarte crassilira.*

ROSTELLITES, Conrad.

ROSTELLITES TEXANA.

PLATE XIV, FIGURE 2, *a*, *b*.

Rostellites Texana, Con. Proc. Acad. Nat. Sci. Vol. VII, p. 268.

Narrow, elongated, with a subulate spire; plaits of columella oblique, straight, narrow, acute, largest above, and becoming obsolete towards the base; volutions of the spire flattened on the sides.

The above genus is probably related to Pterocera. The specimens are very imperfect, only one of them retaining any portion of the shell, and this is the columella with the plaits.

Locality.—Eagle Pass.

NERINEA, Defranc.

NERINEA SCHOTTII.

PLATE XIV, FIGURE 3, *a*, *b*.

Elongated; volutions concave or sub-angulated below the middle; destitute of lines except one slightly impressed line near and below the suture; body volution angulated in the middle.

A large and beautiful species, with the shell converted into carbonate of lime. Named in honor of its discoverer, Arthur Schott, esq.

NODOSARIA, Lam.

NODOSARIA TEXANA.

PLATE XIV, FIGURE 4, *a, b, c.*

Straight or slightly curved, subulate, nodes transversely oblong or depressed, ventricose, numerous.

Very abundant in the form of casts. The outline of the shell appears to have been nearly or quite straight below, and somewhat curved towards the apex.

Locality—Between El Paso and Frontera.

AMMONITES, Lam.

AMMONITES PLEURISEPTA.

PLATE XV, FIG. 1, *a, b, c.*

Discoid, much compressed, lentiform; back acute; volutions with obscure, distant, transverse ribs or undulations, and two series of nodules—one central and distinct, the other obsolete—elongated transversely and near the margin or back; transverse section of the whorls lanceolate; umbilicus very small; series of sutures of the septa crowded, gradually separating as they approach the inmost whorl; septal lobes short, suddenly expanded, crenulate, rounded; saddle bilobed, the lobes obtusely rounded, the third lobe from the dorsal the largest of the series.

This species approximates *A. pedernalis*, Roemer, who supposes it to be identical with the foreign species of that name described by Von Buch. It differs from Roemer's shell in having tubercles, in being less compressed, or forming a less acute angle with the back; in having a smaller umbilicus, and transverse undulations, and also in more crowded and very differently shaped septa. It attains a much larger size than the specimen figured.

Locality.—Jacun, 3 miles below Laredo.

AMMONITES GENICULATUS.

PLATE XV, FIG. 2, *a, b.*

Discoid, sides flattened and gradually sloping towards the back, which is abrupt, slightly rounded, and with a thick, prominent carina on the middle; ribs numerous, slightly curved until they approach the back, when they suddenly bend and become very oblique and more prominent, obsolete on the back; inner sides of the volutions abrupt.

Allied to *A. flaccidicosta*, Roemer, but may be distinguished by the dorsal carina and broader arms of the septal lobes, and flattened instead of rounded volutions; and also by the different form and inclination of the ribs.

Locality.—Bed of Rio San Pedro, and Leon Springs.

AMMONITES TEXANUS.

PLATE XVI, FIG. 1, *a, d.*

Ammonitse Texanus, Roemer; Kreid. von Texas, pl. VI, fig. 2, *a, b.*

Large, somewhat discoidal, involute; volutions subquadrangular, gradually increasing in

height and width, carinated and nodo-costate; dorsal carina continuous, the approximate series of tubercles not equal to it in prominence; ribs numerous, 22 on each volution, equidistant, ornamented with 5 tubercles; series near the dorsal carina compressed, elongated, the others rounded; transverse section of the exterior volution rectangular, of the interior volution quadrate; sutures of septa moderately divided and ramose.

Locality.—Near Puercos river.

AMMONITES LEONENSIS.

PLATE XVI, FIG. 2, *a*, *b*.

Volutions with thick, distant, rounded ribs, with a tubercle on each extremity and an intermediate rudimentary rib, having a tubercle on the dorsal angle; back obliquely truncated on each side of the carina.

This shell differs from *A. Texanus* in having the back elevated in the middle, and in being without tubercles on the back, in having only two series of nodes on the sides, or with a middle series of rudimentary or obsolete tubercles; also the serratures of the septal lobes are much wider than in *A. Texanus*.

TERTIARY FOSSILS.

OSTREA, Lin.

OSTREA VESPERTINA.

PLATE XVII, FIG. 1, *a–d*.

Ostrea vespertina, Con. Jour. Acad. Nat. Sci., vol. II, (new series) p. 300.

Ovate-subfalcate; lower valve plaited or ribbed; hinge long and wide, sharp and somewhat pointed; ligament cavity wide, profound, minutely wrinkled; margins abrupt; cavity not very deep; muscular impressions large, impressed; upper valve flat, irregular; pallial impression crenulated.

Resembles *O. subfalcata*, Con. of the Virginia Miocene.

Localities.—Carriso creek, and near San Diego, California. (Miocene.)

OSTREA VELENIANA.

PLATE XVII, FIG. 2, *a*, *b*.

Ovate, flattened, entire, with rugose lines of growth; cardinal area very broad: ligament pit shallow; muscular impression very large in proportion to the size of the shell, transverse; no crenulations visible about the margin.

This is probably a Miocene shell.

Locality.—Rancho Heleña, below Salado.

OSTREA CONTRACTA.

PLATE XVIII, *a*, *b*, *c*, *d*.

Ostrea contracta, Proc. Acad. Nat. Sci., vol. VII, p. 269.

Subfalcate, elongate, thick; exterior of lower valve very irregular, and varying from ventricose

to flat; cavity shallow and remarkably contracted towards the hinge, which is elongated, having a deep and broad cavity in the lower valve, with a corresponding rounded and striated ridge in the opposite valve.

This large oyster measures nearly two feet from beak to base. The contracted form of the cavity is most striking in the oldest individuals. Probably a Miocene shell.

Locality.—Oyster Point, Mexico.

ANOMIA, Lin.

ANOMIA SUBCOSTATA.

PLATE XIX, FIG. 1 *a*, *b*.

Anomia subcostata, Con. Proc. Acad. Nat. Sc., vol. VII, p. 267.

Obtusely ovate, rather thick; umbo of larger valve ventricose; hinge thickened, surface of the valve obtusely undulated concentrically, and marked with waved, wrinkled, interrupted ribs, much raised, except towards the base, where they are larger and somewhat tuberculiform; upper valve entire, or with obsolete radii towards the base.

This has a general resemblance to *A. Ruffini*, Con., of the Virginia Miocene, but is much thicker and very distinct.

CARDITA, Lam. Blain.

CARDITA PLANICOSTA.

PLATE XIX, FIGURE 2, *a*, *b*.

Venericardia planicosta, Lam. An. sans Vert., vol. V, p. 669. Desh. Coq. Foss., vol. I, p. 149.
Cardita planicosta, Blainville.

Ovate-oblique, cordate, very thick, with flattened broad ribs, 22–24, granulated towards the apex; lunule very profound, wide, cordate, margin crenate within, cardinal teeth two, finely striated.

This species is found in Virginia and Alabama, as well as in California. Deshayes describes the Paris specimens of *C. planicosta* as crenulated on the ribs near the summit, a character scarcely visible in the specimens that I have examined.

Locality.—Arroyo las Minas, between Eagle Pass and Leon.

CORBULA, Lam.

CORBULA NASUTA.

PLATE XIX, FIGURE 4.

Corbula nasuta, Con. Foss. Shells of Tert. Form.
Corbula Alabamiensis, Lea, Cont. p. 45, pl. I, fig. 12.

Inflated, triangular-ovate, very inequivalve, ventricose; finely striated concentrically; buccal end rounded, longer than the anal, which is contracted; flexuous, narrow, and obliquely truncated at the end.

Locality.—Western Texas.

VENUS VESPERTINA.

PLATE XIX, FIGURE 5, *a*, *b*.

Subtriangular, inequilateral, convex; length and height equal; buccal end acutely rounded; anal end more obtuse; summit prominent.

A small Eocene species, with the external surface somewhat worn. It appears to have had concentric lines.

Locality.—Western Texas.

CYTHEREA, Lam.

CYTHEREA NUTTALI.

PLATE IV, FIGURE 5.

Cytherea Nuttali, Con. Foss. Shells of Tert. Form.

Subrotund, inflated, equilateral, ornamented with fine, regular, concentric lines, anal end obtusely rounded.

An Eocene species, found both in Texas and Alabama.

Locality.—East of Frontera, associated with *Cassidula alveata*.

VOLUTALITHES, Swainson.

VOLUTALITHES SAYANA.

PLATE XIX, FIGURE 6.

Voluta Sayana, Con. Foss. Shells of Tert. Form.
Voluta Defrancii, Lea, Cont., p. 171, pl. VI, fig. 179.
Voluta gracilis, Lea, Cont., p. 172, pl. VI, fig. 180.
Voluta parva, Lea, Cont., p. 173, pl. VI, fig. 181.

Turbinate, with revolving impressed lines; coronated; shell thin; volutions 7, subangulated; body volution either smooth or with longitudinal acute lines or folds.

There is only one small specimen of this abundant Claiborne species. It is imbedded in the same piece of rock which contains *Corbula nasuta* and *Natica limula*.

Locality.—Western Texas.

NATICA, Lam.

NATICA LIMULA.

PLATE XIX, FIGURE 7.

Natica limula, Con. Foss. Shells of Tert. Form.
Natica mamma, Lea, Cont. to Geol., p. 109, pl. IV, fig. 95.

Subglobose, flattened at base; spire rounded, pointed at the apex; columella much thickened above; umbilicus large; shell thin; mouth ovate.

Locality.—Same as preceding.

TURRITELLA, Lam.

TURRITELLA ———.

PLATE XIX, FIGURE 8.

This figure represents a specimen of tertiary rock from San Diego, California. Besides the *Turritella*, which is not determined, there are a few small unknown bivalves.

CASSIDULA, Humphreys. Sub-genus LACINIA, Con.

CASSIDULA ALVEATA.

PLATE XIX, FIGURE 9.

Melongena alveata, Con., Amer. Jour. Sci., vol. XXIII, p. 344.
Cassidula alveata, Con., Proc. Acad. Nat. Sci., vol. VII, p. 448.
Pyrula Smithii, Lea, Cont. to Geol., p. 153, pl. V, fig. 162.

Sub-globose, with revolving robust lines, and a wide, concave, revolving furrow below the angle of the large volution; spire very short; suture deeply impressed, sub-canaliculate.

Locality.—Western Texas.

APPENDIX.

CRETACEOUS FOSSILS.

CARDITA SUBTETRICA.

PLATE XXI, FIGURE 5.

Sub-orbicular, slightly ventricose; ribs 22? not very prominent, rounded, squamose, ribs and interstices about equal in width.

This may be an eocene species; I do not know any of its associated fossils.

Locality.—Rio Bravo del Norte.

PHOLADOMYA SANCTI-SABÆ.

PLATE XXI, FIGURE 4.

Cardium Sancti-Sabœ, Rœmer, Kreide. von Texas, p. 48, pl. VI, fig. 7.

Inequilateral, longitudinally ovate, gibbous, posteriorly compressed, produced, sub-caudate, smooth; the rest of the shell radiate-costate; ribs 16, equal, granulated, becoming obsolete posteriorly; umbo large, prominent, anterior to the middle.

Localities.—Leon Springs; New Braunfels, Texas.

CAPSA, Lam.

CAPSA TEXANA.

PLATE XXI, FIGURE 6.

Oblong-oval, disk flattened or depressed in the middle; radii distinct, close, rugose posteriorly, gradually becoming obsolete in the middle of the valve; buccal end regularly rounded; anal end truncated, direct.

Locality.—Leon Springs.

TEREBRATULA LEONENSIS.

PLATE XXI, FIGURE 2.

Inequivalved, oval or sub-petagonal; rostral end ventricose, rounded in the middle, and the sides obliquely convex-depressed; umbo small; foramen small, almost touching the umbo; imperforate valve less convex; valve widest above the middle, rapidly tapering to the front, which is slightly depressed; front margin narrow and truncated; surface elegantly and minutely punctate.

Narrower in front than *T. Wacoensis*, Rœmer. I cannot compare it with Shumard's figure of *T. Choctawensis*, as that figure, in the Palæontology of Red river, like all the representations of fossils in that work, (except *Gryphœa Pitcheri,*) is worthless for the purpose of identification. The punctuated surface is so common in the genus that it has no value in specific distinctions.

Locality.—Leon Springs.

TURRITELLA LEONENSIS.

PLATE XXI, FIGURE 7, *a*, *b*.

Volutions sub-angular, each with three distant, large, crenulated, revolving ribs, and an intermediate crenulated line; spire rapidly tapering to the apex; body volution large, rounded at base, which has four or five fine revolving ribs.

A limestone cast; traces of shell show oblique longitudinal folds or ribs.

HAMITES LARVATUS.

PLATE XXI, FIGURE 8.

Hamites larvatus, Con. Proc. Acad. Nat. Sci., vol. VII, p. 265.

Ovate-oval, obliquely ribbed; beak and front obtusely rounded or sub-truncated; ribs oblique, distant, very prominent, acute, unequal, frequently alternated, obsolete on the back, and having a tubercle on the front margin or angle; ribs on the front thickened and obtuse; sides of the shell flattened, and the rib margin nearly rectilinear; smaller ribs generally without a distinct tubercle.

I have amended the former description of this species from the specimen here figured. In the Arkansas specimen the ribs are alternated, the smaller one being without a tubercle; but the former has three equal ribs with the tubercle on each, and above them is the smaller rib without it. Traces of the shell show annular striæ.

Localities.—Leon Springs, Texas; White river, Arkansas.

EXPLANATION OF PLATES OF PROFESSOR HALL'S REPORT.

PLATE I.

FIG. 1.—PYRINA PARRYI.

Fig. 1 *a*. Upper side.
1 *b*. Lower side.
1 *c*. Posterior side.
1 *d*. Enlargement of the surface showing the larger and smaller granulations, ambulacral pores, etc.

FIG. 2.—TOXASTER TEXANUS.

Fig. 2 *a*. View of the base.
2 *b*. View of the summit.
2 *c*. Posterior view.

FIG. 3.—CYPHOSOMA TEXANUM.

Fig. 3 *a*. Profile view.
3 *b*. View of base.
3 *c*. Enlargement of ambulacral and interambulacral spaces, (figures from Roemer.)

FIG. 4.—HOLECTYPUS PLANATUS.

Fig. 4 *a*. Profile view.
4 *b*. Summit.
4 *c*. Base.
4 *d*. Enlargement of the summit of the test.
4 *e*. Enlargement of the ambulacral and interambulacral spaces.
4 *f*, *g*. Base of attachment of spine enlarged.

PLATE II.

FIG. 1.—CAPRINA OCCIDENTALIS.

Fig. 1 *a*, *b*. Upper and lower sides.
1 *c*. Transverse section.

FIG. 2.—CAPRINA PLANATA.

Fig. 2 *a*. A fragment one third the linear dimensions.
2 *b*. Enlargement showing structure.

FIG. 3.—TURBINOLIA TEXANA

Fig. 3 *a*. Specimen natural size.
3 *b*. Enlargement of the lamellae.

PLATE III.

FIG. 1.—TEREBRATULA WACOENSIS.

Fig. 1 *a*. Dorsal view.
1 *b*. Ventral view.
1 *c*. Profile view.
1 *d*. Enlargement of surface.

FIG. 2.—TRIGONIA EMORYI.

Fig. 2 *a*. Posterior view.
2 *b*. Anterior view.
2 *c*. Right valve.

FIG. 3.—TRIGONIA TEXANA.

Fig. 3 *a*. Lateral view.
3 *b*. Posterior view.
3 *c*. Anterior view.

PLATE IV.

FIG. 1.—MACTRA TEXANA.

Fig. 1 *a*. Lateral view.
1 *b*. Cardinal view.

FIG. 2.—CUCULLEA TERMINALIS.

Fig. 2 *a*. Lateral view.
2 *b*. Anterior cardinal view.

FIG. 3.—ARCOPAGIA TEXANA.

Fig. 3 *a*. Lateral view.
3 *b*. Cardinal view.

FIG. 4.—CYTHEREA NUTTALLI.

Fig. 4 *a*. Lateral view.
4 *b*. Cardinal view.

PLATE V.

FIG. 1.—NEITHEA OCCIDENTALIS.

Fig. 1 *a*. Lower valve.
1 *b*. Profile view.
1 *c*. Enlargement of the surface.

FIG. 2.—NEITHEA TEXANA.

Fig. 2 *a*. Lower valve.
2 *b*. Enlargement of surface.

FIG. 3.—LIMA LEONENSIS.

Fig. 3 *a*. Right valve.
3 *b*. Postero-cardinal view.
3 *c*. Enlargement of surface.

FIG. 4.—LIMA WACOENSIS.

Fig. 4 *a*, *b*. Lateral and cardinal views.

FIG. 5.—INOCERAMUS CONFERTIM ANNULATUS.

FIG. 6.—INOCERAMUS MYTILOPSIS.

Fig. 6 *a*. Figure, (after Roemer.)
6 *b*. Fragment of New Mexican specimen.

FIG. 7.—INOCERAMUS TEXANUS.

FIG. 8.—INOCERAMUS CRISPII.

FIG. 9.—ASTARTE TEXANA.

PLATE VI.

FIG. 1.—CYTHEREA LEONENSIS.

FIG. 2.—CYTHEREA TEXANA.

FIG.—3.—ARCA SUB-ELONGATA.

Fig. 3 *a*. Left valve.
3 *b*. Cardinal view.

FIG. 4.—CARDIUM MULTISTRIATUM.

Fig. 4 *a*. Right valve.
4 *b*. A larger individual.
4 *c*. Profile view.

FIG. 5.—CARDIUM CONGESTUM.

Fig. 5 *a*. Right valve.
5 *b*. Posterior view.
5 *c*. A larger individual.
5 *d*. Profile of same.

FIG. 6.—CARDIUM TEXANUM.

Fig. 6 *a*. Right valve.
6 *b*. Posterior view.
6 *c*. Anterior view.

FIG. 7.—CARDIUM FILOSUM.

Fig. 7 *a*. Left valve.
7 *b*. Enlargement of surface.

FIG. 8.—CARDITA EMINULA.

Fig. 8. Lateral and profile views.

FIG. 9.—CORBULA OCCIDENTALIS.

FIG. 10.—PLICATULA INCONGRUA.

Fig. 10 *a*. Lower valve.
10 *b*. Upper valve and interior of lower valve.

PLATE VII.

FIG. 1.—EXOGYRA ARIETENUM.

Fig. 1 *a*. Upper valve, exterior view.
1 *b*. Upper valve, interior.
1 *c*. Lower valve.
1 *d*, *e*. Two views, same specimen.

FIG. 2.—EXOGYRA FOLIACEA.

Fig. 2 *a*. Upper valve, exterior surface.
2 *b*. Upper valve, interior surface.

FIG. 3.—GRYPHÆA PITCHERI.

Fig. 3 *a*. Lower valve, exterior surface.
3 *b*. View of upper side of shell, with valves attached.
3 *c*. Profile of large valve.
3 *d*. Large valve, variety *navia*.
3 *f*. Upper valve, exterior view.
3 *g*. Upper valve, interior view.

FIG. 4.—GRYPHÆA LÆVIUSCULA.

Fig. 4 *a*. Lower valve.
4 *b*. Profile of same.

PLATE VIII.

FIG. 1.—EXOGYRA MATHERONIANA.

Fig. 1 *a*. Lower valve.
1 *b*. Anterior view.

FIG. 2.—EXOGYRA FRAGOSA.

Fig. 2 *a*. Lower valve, exterior view.
2 *b*. Lower valve, interior view.

FIG. 3.—EXOGYRA TEXANA—variety.

PLATE IX.

FIG. 1.—EXOGYRA COSTATA—variety.

Fig. 1. Exterior view of specimen fig. 3 of the preceding plate.

FIG. 2.—EXOGYRA COSTATA.

Fig. 2 *a*. Exterior view of lower valve.
2 *b*. Interior of lower valve.

PLATE X.

FIG. 1.—EXOGYRA COSTATA.

Fig. 1. Exterior view of the lower valve, showing the obsolescent character of the costæ.

FIG. 2.—GRYPHÆA PITCHERI.

Fig. 2 *a*. Exterior of upper valve.
2 *b*. Interior of the same.

FIG. 3.—OSTREA SUBSPATULATA.

Fig. 3 *a*. Exterior view of the upper valve.
3 *b*. Interior of the same.

FIG. 4.—OSTREA BELLA.

Fig. 4 *a*. View of the upper side of the two valves attached.
4 *b*. Lower valve, exterior view.

FIG. 5.—OSTREA LUGUBRIS.

Fig. 5 *a*, *b*. Exterior and interior of lower valve.

FIG. 6.—OSTREA CARINATA.

PLATE XI.

FIG. 1.—EXOGYRA MATHERONIANA.

Fig. 1 *a*, *b*. Exterior and interior views of lower valve.

FIG. 2.—OSTREA VELLICATA.

Fig. 2 *a*, *b*. Exterior and interior views of lower valve.

FIG. 3.—OSTREA ROBUSTA.

Fig. 3 *a*. Upper side, with the shell exfoliated.
3 *b*. Lower side, retaining the shell, in part.

FIG. 4.—OSTREA CORTEX.

Fig. 4 *a*, *b*. Exterior and interior of a lower valve.
4 *c*, *d*. Exterior and interior of an upper valve.

PLATE XII.

FIG. 1.—OSTREA MULTILIRATA.

Fig. 1 *a*, *b*. Exterior and interior of upper valve.
1 *c*, *d*. Exterior and interior of lower valve, showing a different form.

PLATE XIII.

FIG. 1.—NATICA TEXANA.

Fig. 1 *a*, *b*. Two views of same specimen.

FIG. 2.—NATICA COLLINA.

Fig. 2 *a*, *b*. Two views of the same specimen.

FIG. 3.—ROSTELLARIA? COLLINA.

Fig. 3 *a*, *b*. Two views of the same specimen.

FIG. 4.—ROSTELLARIA? TEXANA.

Fig. 4 *a*, *b*. Two views of the same specimen.

FIG. 5.—BUCCINOPSIS PARRYI.

Fig. 5 *a*, *b*. Two views of the same specimen.

PLATE XIV.

FIG. 1—TURRITELLA PLANILATERIS.

Fig. 1 *a*. A fragment of the shell, natural size.
1 *b*. A part of the surface, enlarged.

FIG. 2.—ROSTELLITES TEXANA.

Fig. 2 *a*, *b*. Two views of same specimen.

FIG. 3.—NERINEA SCHOTTII.

Fig. 3 *a*, *b*. Two views of same specimen.

FIG. 4—NODOSARIA TEXANA.

Fig. 4 *a*. Exterior view of specimen, enlarged.
4 *b*. Longitudinal section.
4 *c*. A transverse section.

PLATE XV.

FIG. 1.—AMMONITES PEDERNALIS, (Var.)

Fig. 1 *a*. Lateral view.
1 *b*. Front view.
1 *c*. Plan of septa, enlarged.

FIG. 2.—AMMONITES GENICULATUS.

Fig. 2 *a*. Lateral view.
2 *b*. Front view.

PLATE XVI.

FIG. 1.—AMMONITES TEXANUS.

Fig. 1 *a*. Lateral view.
1 *b*. View of aperture.
1 *c*. Plan of septa, enlarged.
1 *d*. Young variety, (after Rœmer.)

FIG. 2.—AMMONITES LEONENSIS.

Fig. 2 *a*. Lateral view.
2 *b*. Aperture, &c.

PLATE XVII.

FIG. 1—OSTREO VESPERTINA.

Fig. 1 *a*, *b*. Exterior and interior of upper valve.
1 *c*, *d*. Exterior and interior of lower valve.

FIG. 2.—OSTREO VELENIANA.

Fig. 2 *a*, *b*. Exterior and interior of upper valve.

PLATE XVIII.

FIG. 1.—OSTREA CONTRACTA.

Fig. 1 *a*. Exterior view of a narrow valve.
1 *b*. Exterior view of a shell of the usual form.
1 *c*. Interior and lateral view of larger valve. (Figures one-third, in linear measurement, of the originals.)
1 *d*. Enlargement of surface of the ligamental pit.

PLATE XIX.

FIG. 1.—ANOMIA SUBCOSTATA.

Fig. 1 *a*, *b*. Exterior and interior of lower valve.

FIG. 2.—CARDITA PLANICOSTA.

Fig. 2 *a*. Left valve, natural size.
2 *b*. Enlargement of surface, showing concentric striæ.

FIG. 3.—PHOLADOMYA TEXANA.

FIG. 4.—CORBULA NASUTA.

FIG. 5.—VENUS VESPERTINA.

Fig. 5 *a*. Right valve, natural size.
5 *b*. Enlargement of surface.

FIG. 6.—VOLUTALITHES SAYANA.

FIG. 7.—NATICA EMINULA.

FIG. 8.—TURRITELLA ——?

FIG. 9.—CASSIDULA (LACINIA) ALVEATA.

Fig. 9 *a*. View of the aperture.
9 *b*. Back of the shell.

PLATE XX.

FIG. 1.—COLUMNARIA THOMI.

Fig. 1 *a*. A fragment of stone with the coral, (ends of columns,) natural size.
1 *b*. Lateral view of same.
1 *c*. Longitudinal section enlarged.
1 *d*. Transverse section enlarged.

FIG. 2.—TEREBRATULA MEXICANA.

Fig. 2 *a*, *b*, *c*. Dorsal, ventral and profile views.

FIG. 3.—ORTHIS ARACHNOIDES?

Fig. 3 *a*. Shell, natural size.
3 *b*. Enlargement of striæ.

FIG. 4.—EUOMPHALUS MICHLERANUS.

FIG. 5.—ASAPHUS EMORYI.

PLATE XXI.

FIG. 1.—HOLASTER ELEGANS.

Fig. 1 *a*. View of summit of specimen.
1 *b*. Base of same.
1 *c*. Posterior, profile view.
1 *d*. Lateral view, profile in outline.
1 *e*. Enlargement of surface.

FIG. 2.—TEREBRATULA LEONENSIS.

Fig. 2 *a*, *b*. Dorsal and profile views.
2 *c*. Enlargement, showing punctate character of shell.

FIG. 3.—GRYPHÆA PITCHERI.

Fig. 3 *a*. View of upper side of specimen with the two valves attached.
3 *b*. Exterior of the lower valve of same.
3 *c*. Interior of lower valve of a smaller individual.

FIG. 4.—PHOLODOMYA, SANCTA-SABLÆ.

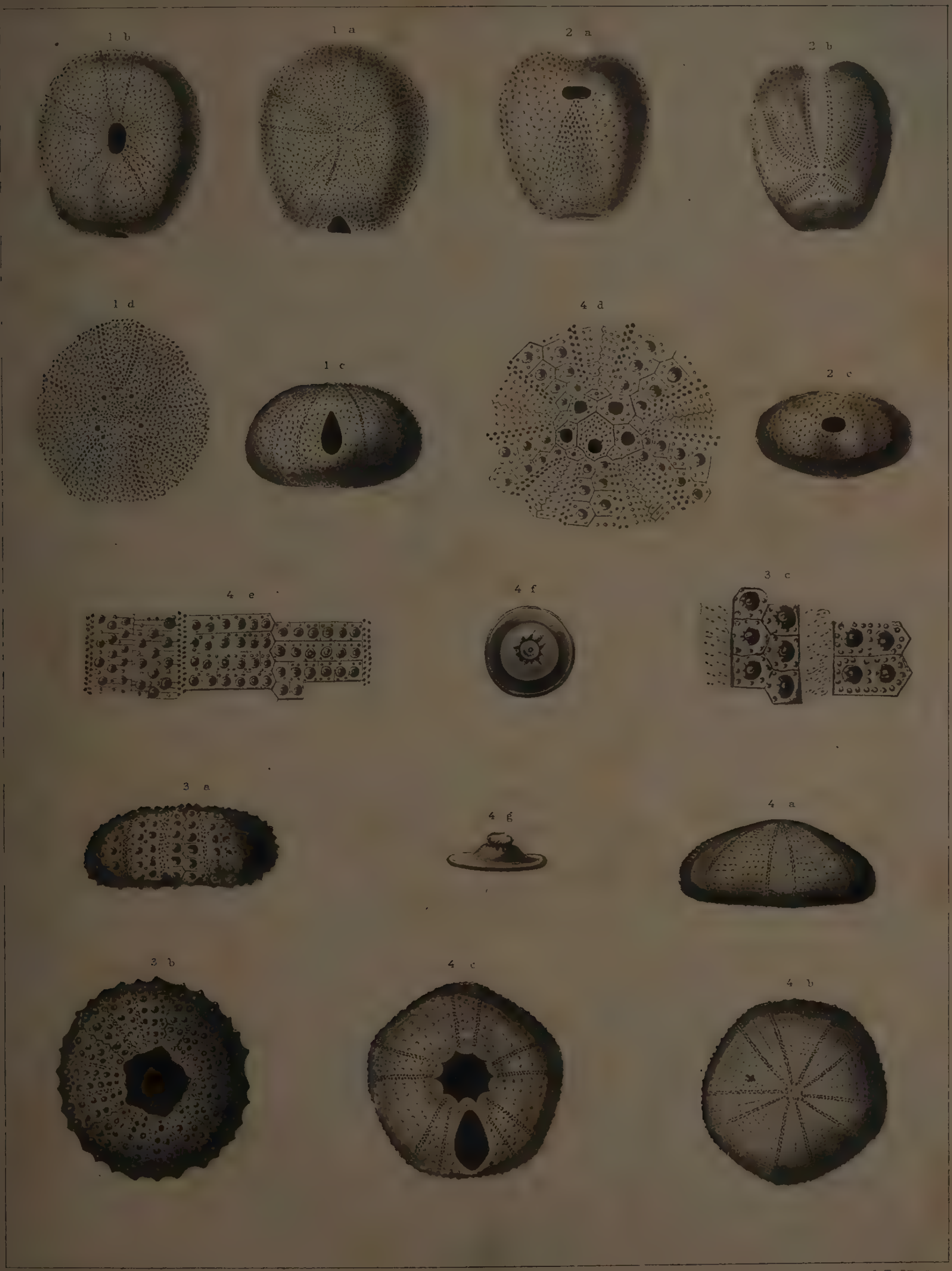
FIG. 5.—CARDITA SUBTETRICA.

FIG. 6.—CAPSA TEXANA.

FIG. 7.—TURRITELLA LEONENSIS.

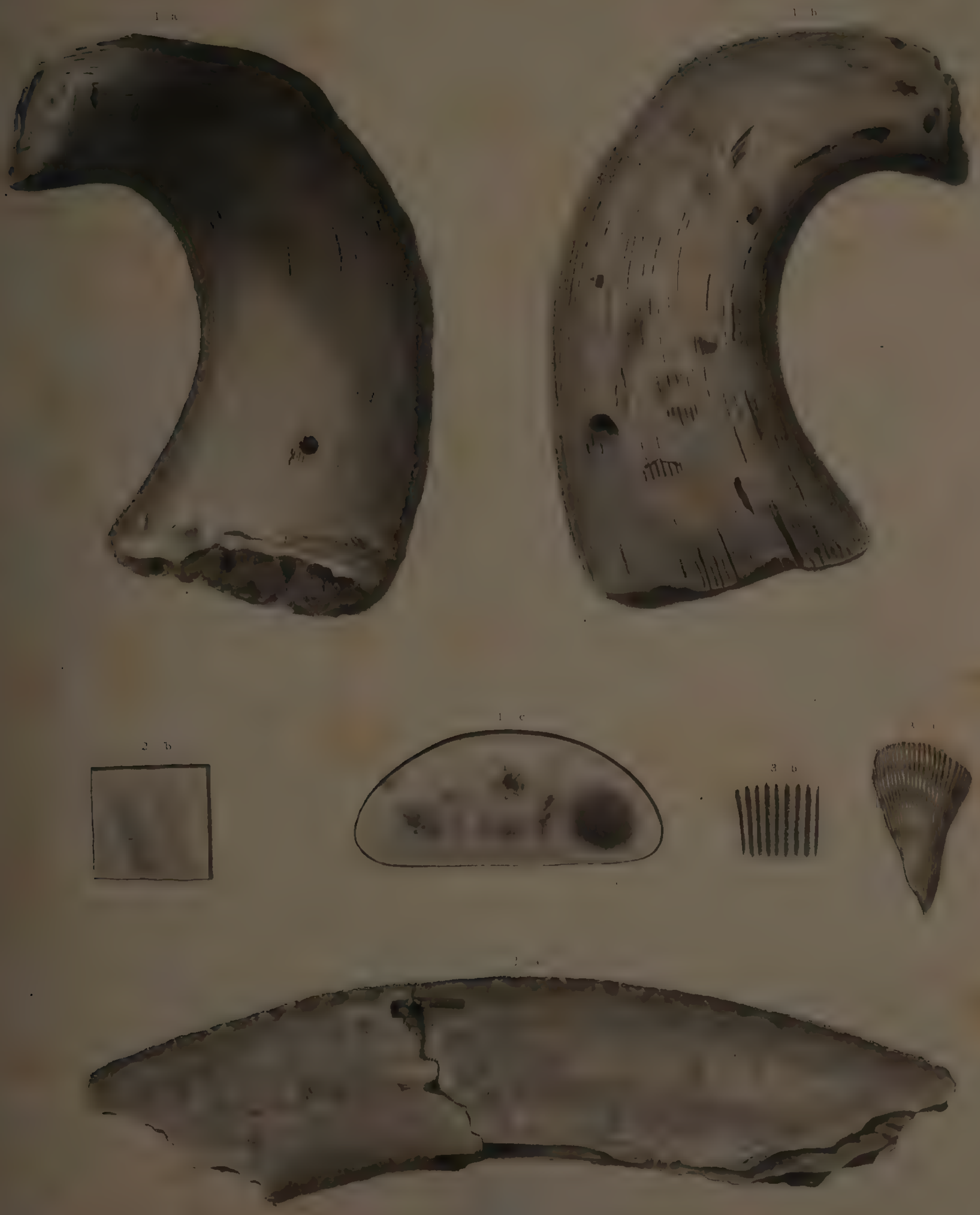
Fig. 7 *a*, *b*. Two views of the same individual.

FIG. 8.—HAMITES LARVATUS.



F. B. Meek del. J. E. Gavit sc.

1 PYRINA PARRYI. 2 TOXASTER TEXANUS. 3 CYPHOSOMA TEXANUM. 4 HOLECTYPUS PLANATUS.

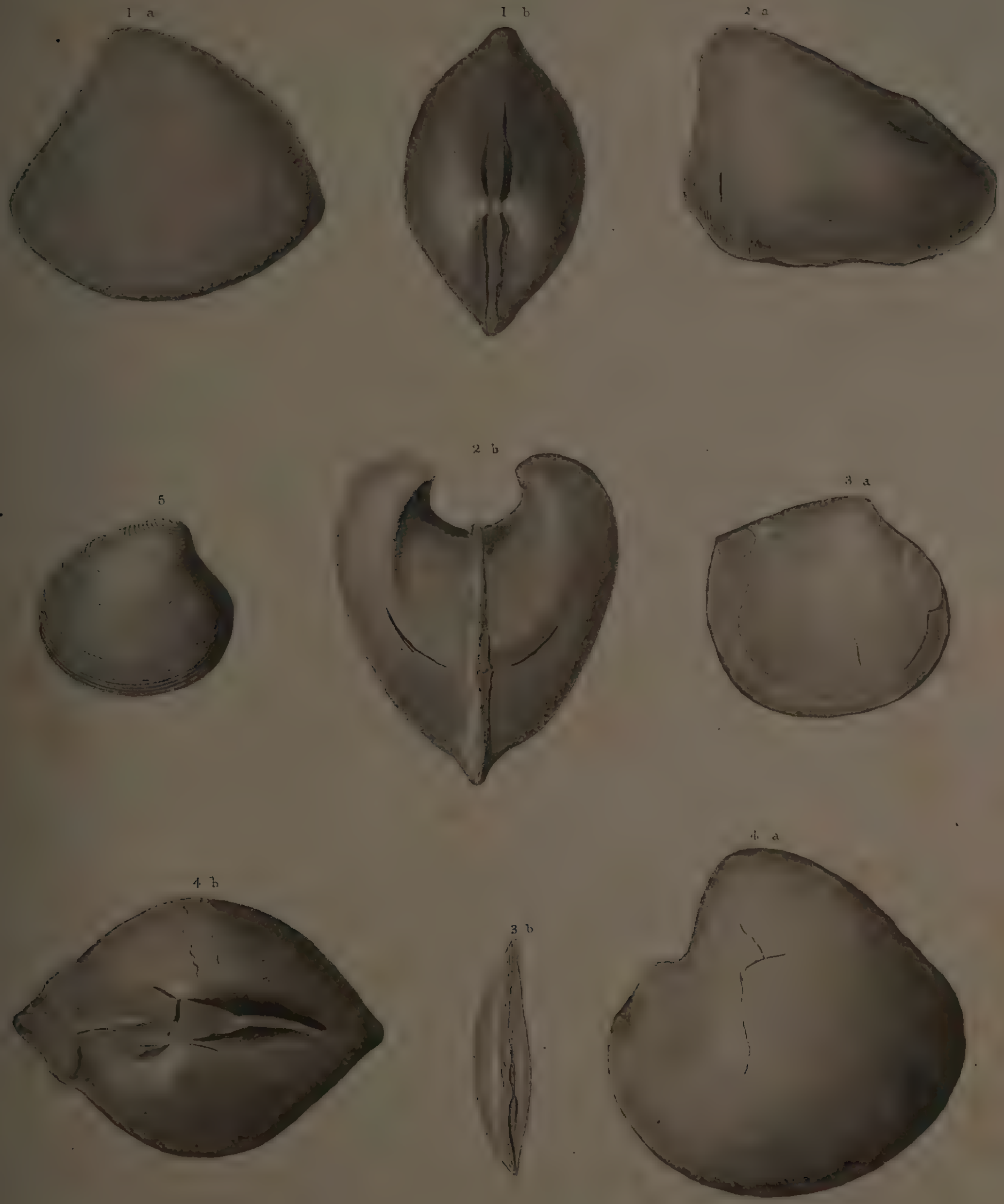


F B Meek del W H Dougal Sc

1 CAPRINA OCCIDENTALIS. 2 C PLANATA. 3 TURBINOLIA TEXANA.

F. B. Meek del. J. E. Gavit sc.

1. TEREBRATULA WACOENSIS. 2. TRIGONIA EMORYI. 3. TRIGONIA TEXANA.

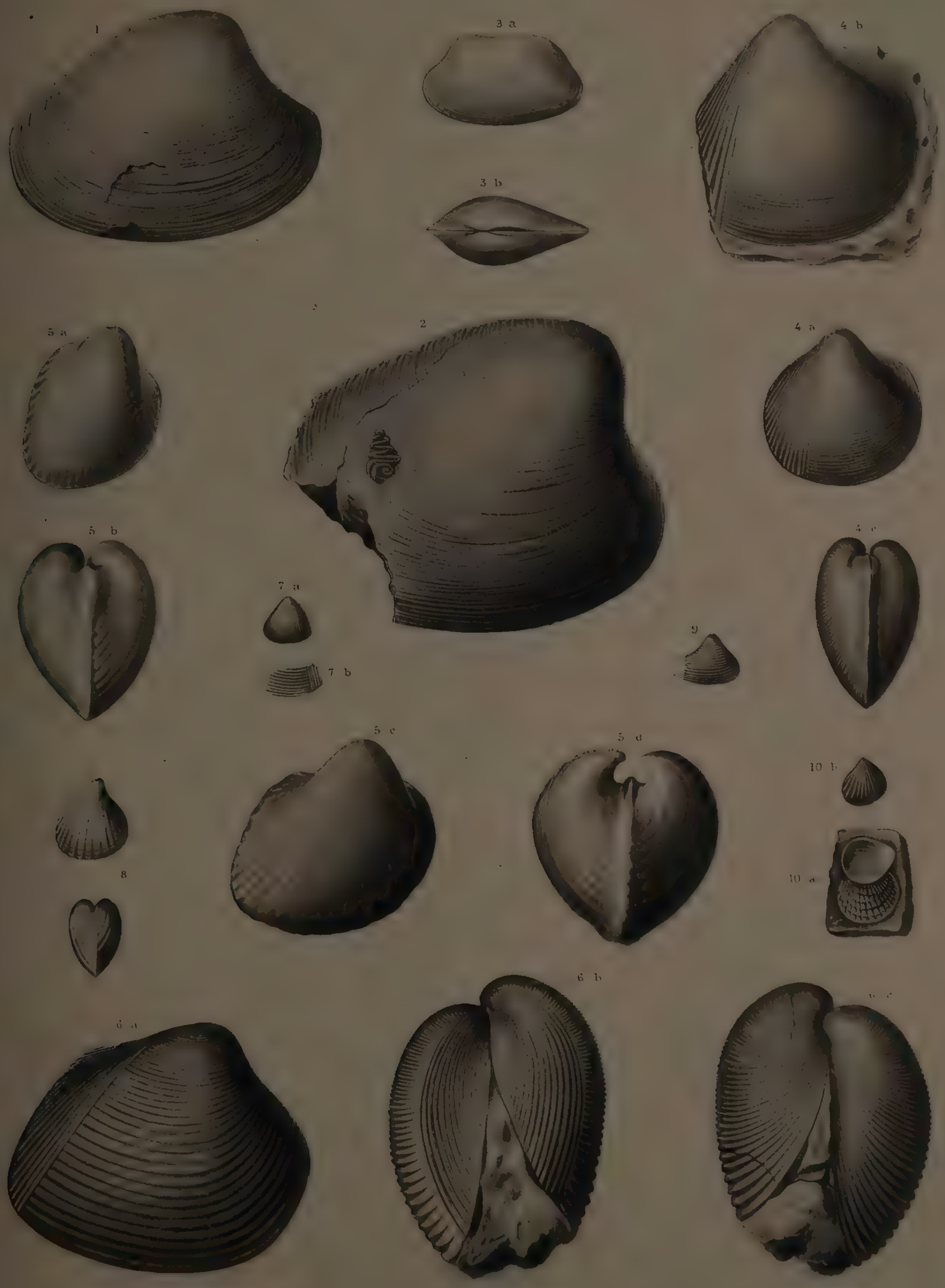


F B Meek del   J E Gavit sc.

1 MACTRA TEXANA. 2 CUCULLEA TERMINALIS. 3 ARCOPAGIA TEXANA. 4 CARDIUM MEDIALE. 5 CYTHEREA NUTTALLII (Eocene sp)

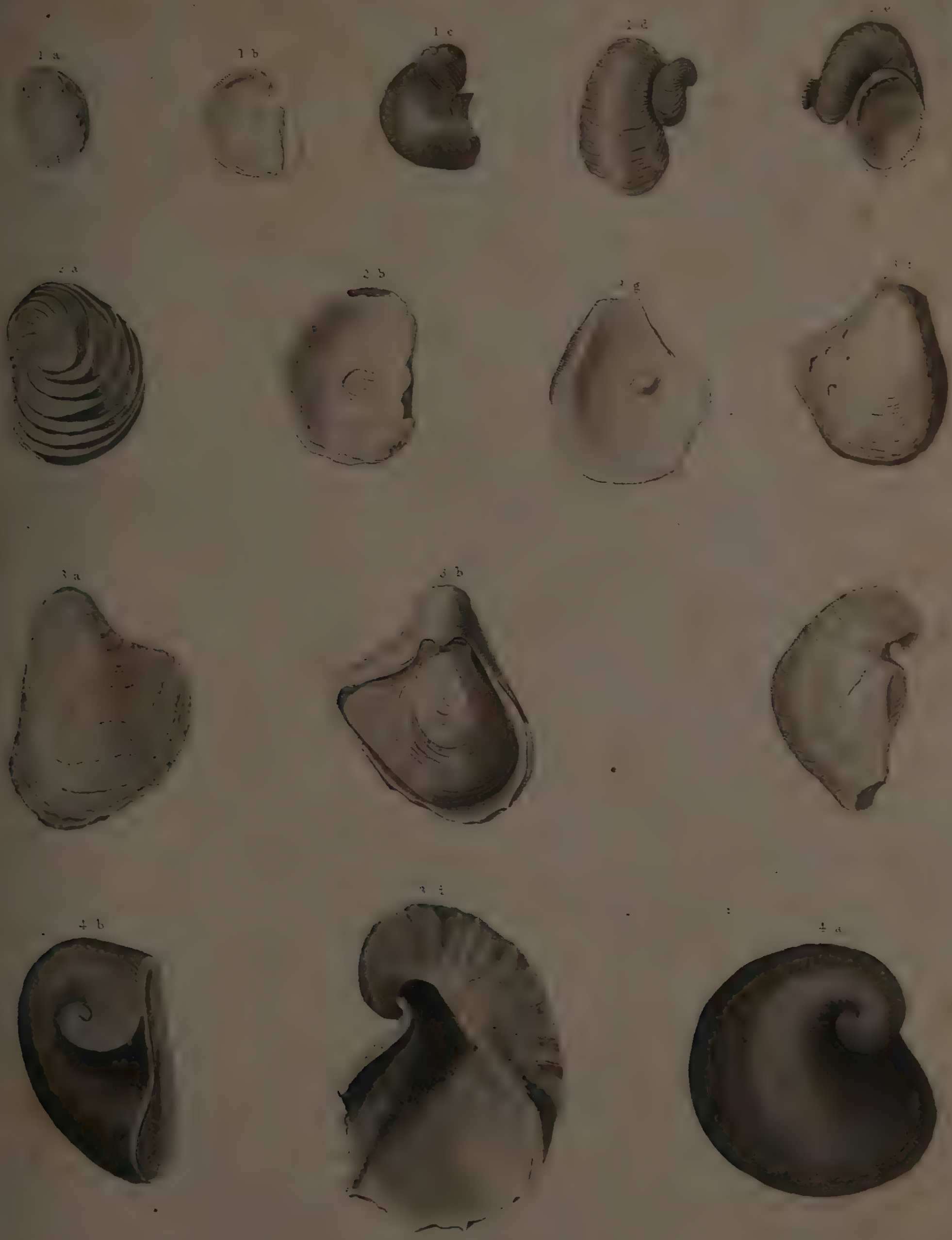
F B Meek del J.E.Gavit sc.

1. NEITHA OCCIDENTALIS. 2 NEITHA TEXANA. 3 LIMA LEONENSIS. 4 LIMA WACOENSIS. 5 INOCERAMUS CONFERTIM-ANNULATUS.
6 INOCERAMUS MYTILOPSIS. 7 INOCERAMUS TEXANUS. 8 INOCERAMUS CRISPII. 9 ASTARTE TEXANA.



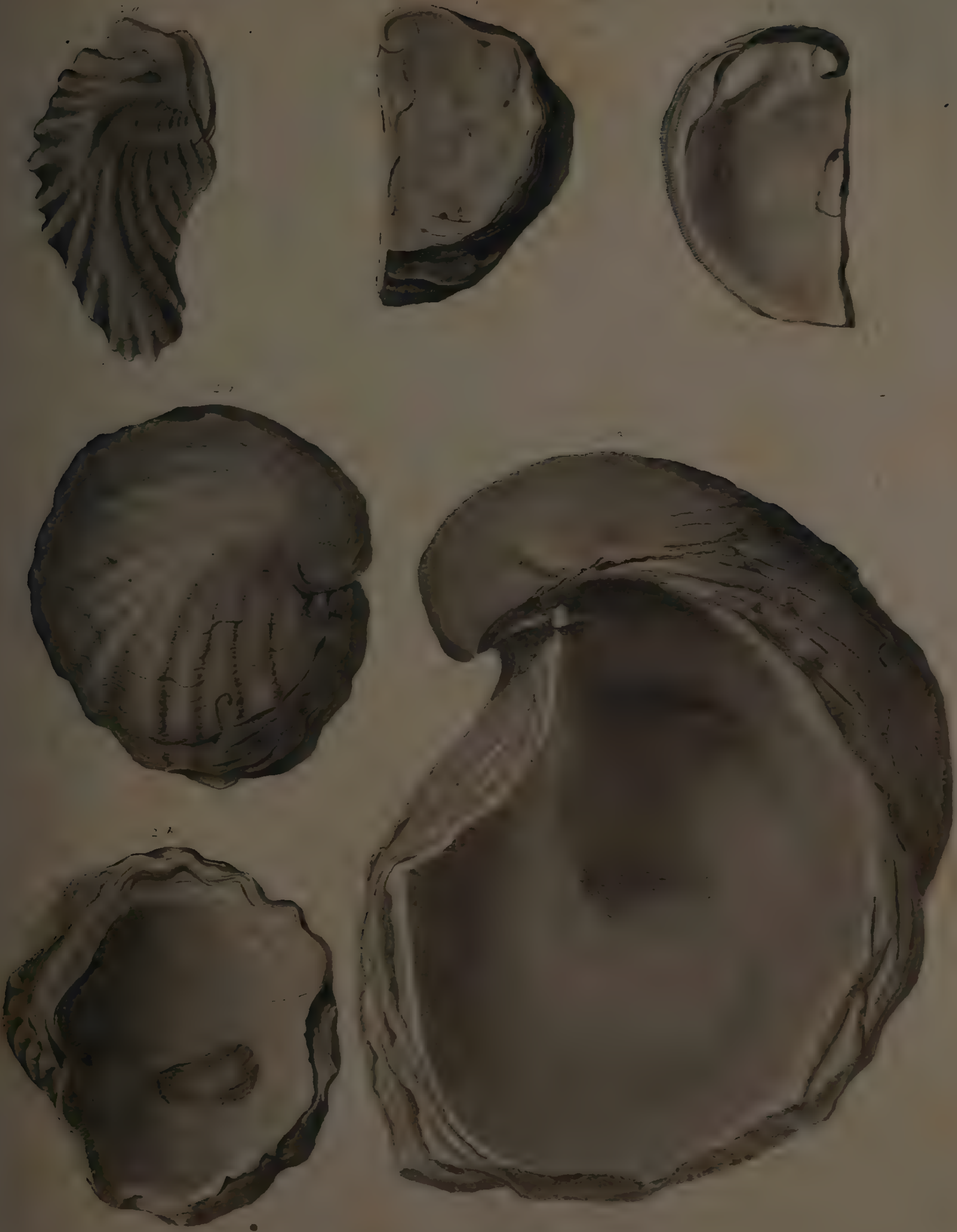
F. B. Meek Del W H Dougal Sc

1 CYTHEREA LEONENSIS. 2 C. TEXANA. 3 ARCA SUBELONGATA. 4 CARDIUM MULTISTRIATUM. 5 C. CONGESTUM. 6 C. TEXANUM. 7 C. FILOSUM.
8 CARDITA EMINULA. 9 CORBULA OCCIDENTALIS. 10 PLICATULA INCONGRUA.

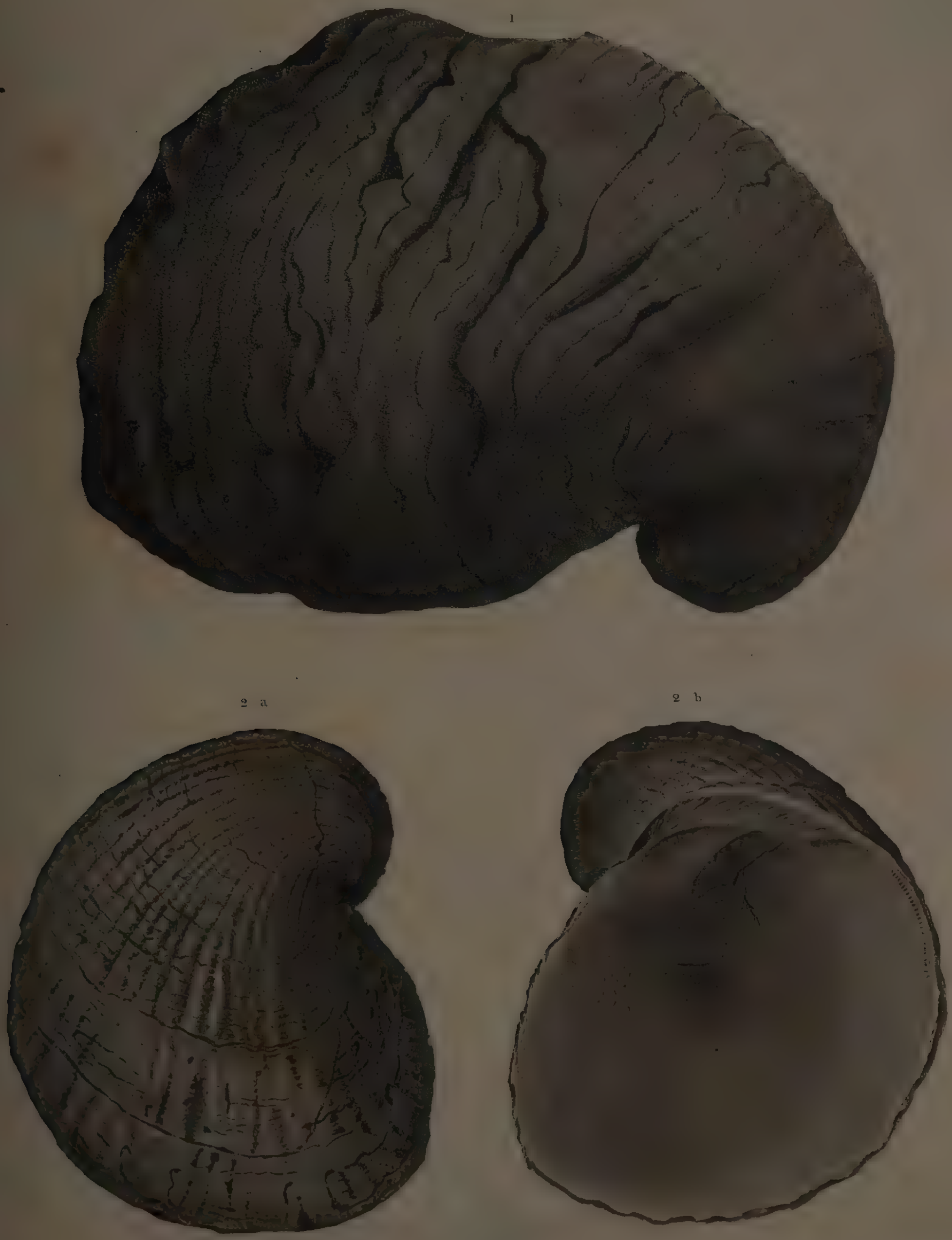


F B Meek del J E Gavit sc

1 EXOGYRA ARIETINUM. 2 EXOGYRA FOLIACEA. 3 GRYPHÆA PITCHERI. 4 GRYPHÆA LÆVIUSCULA.

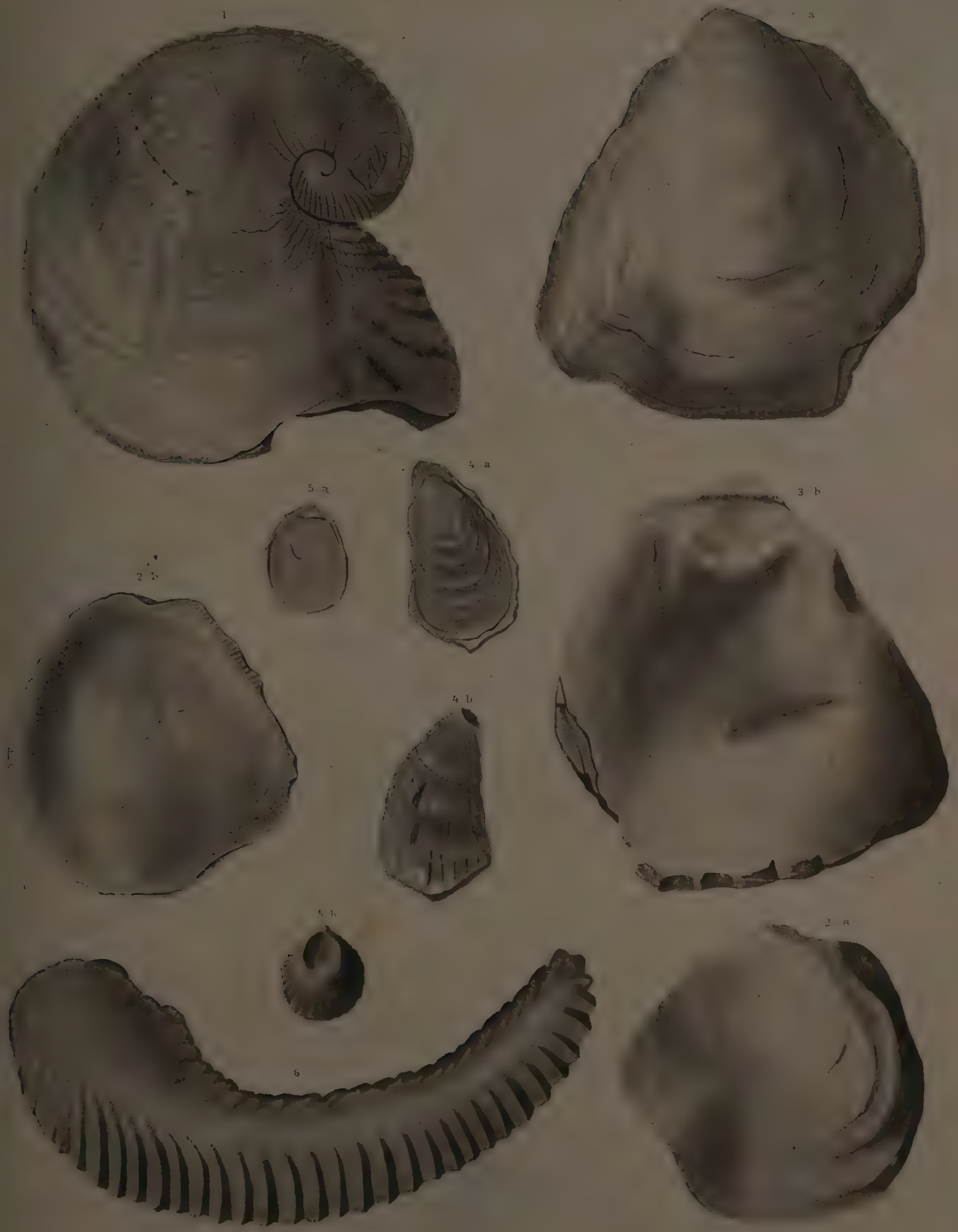


1 EXOGYRA MATHERONIANA. 2 EXOGYRA FRAGOSA 3 EXOGYRA COSTATA VAR



F. B. Meek del. J. E. Gavit sc.

1 EXOGYRA COSTATA VAR. 2 EXOGYRA COSTATA.



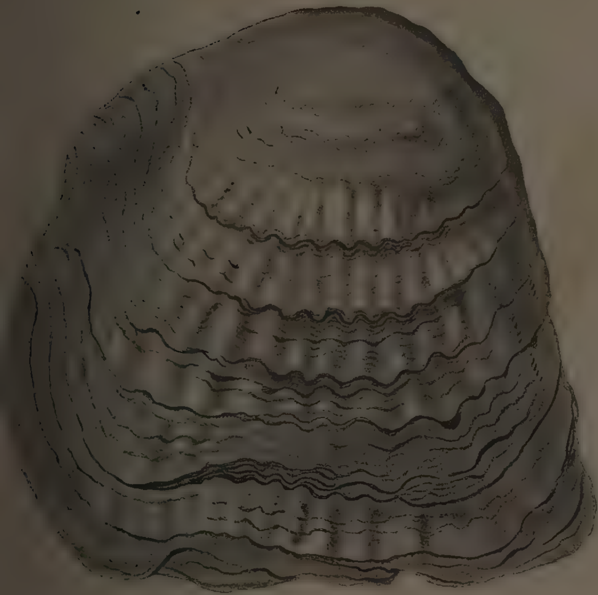
Meek del J E Gavit sc

1 EXOGYRA COSTATA 2 GRYPHÆA PITCHERI 3 OSTREA SUBSPATULATA 4 OSTREA BELLA 5 OSTREA LUGUBRIS 6 OSTREA CARINATA

[illegible] W. H. Dougal Sc

1 EXOGYRA MATHERONIANA. 2 OSTREA VELLICATA. 3 O. ROBUSTA. 4 O. CORTEX

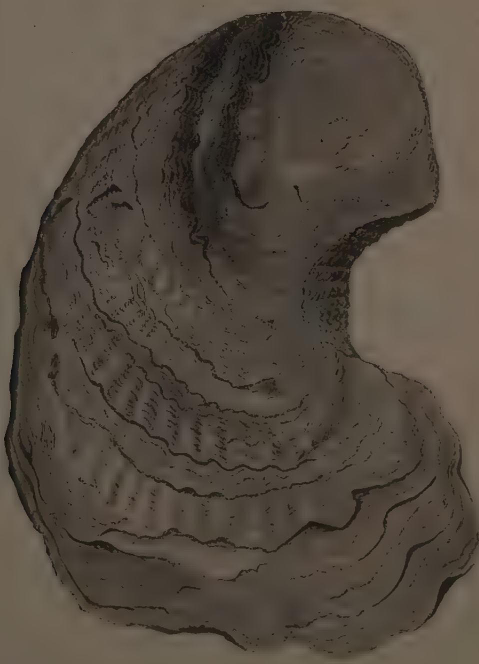
1 a



1 c

1 b

1 d

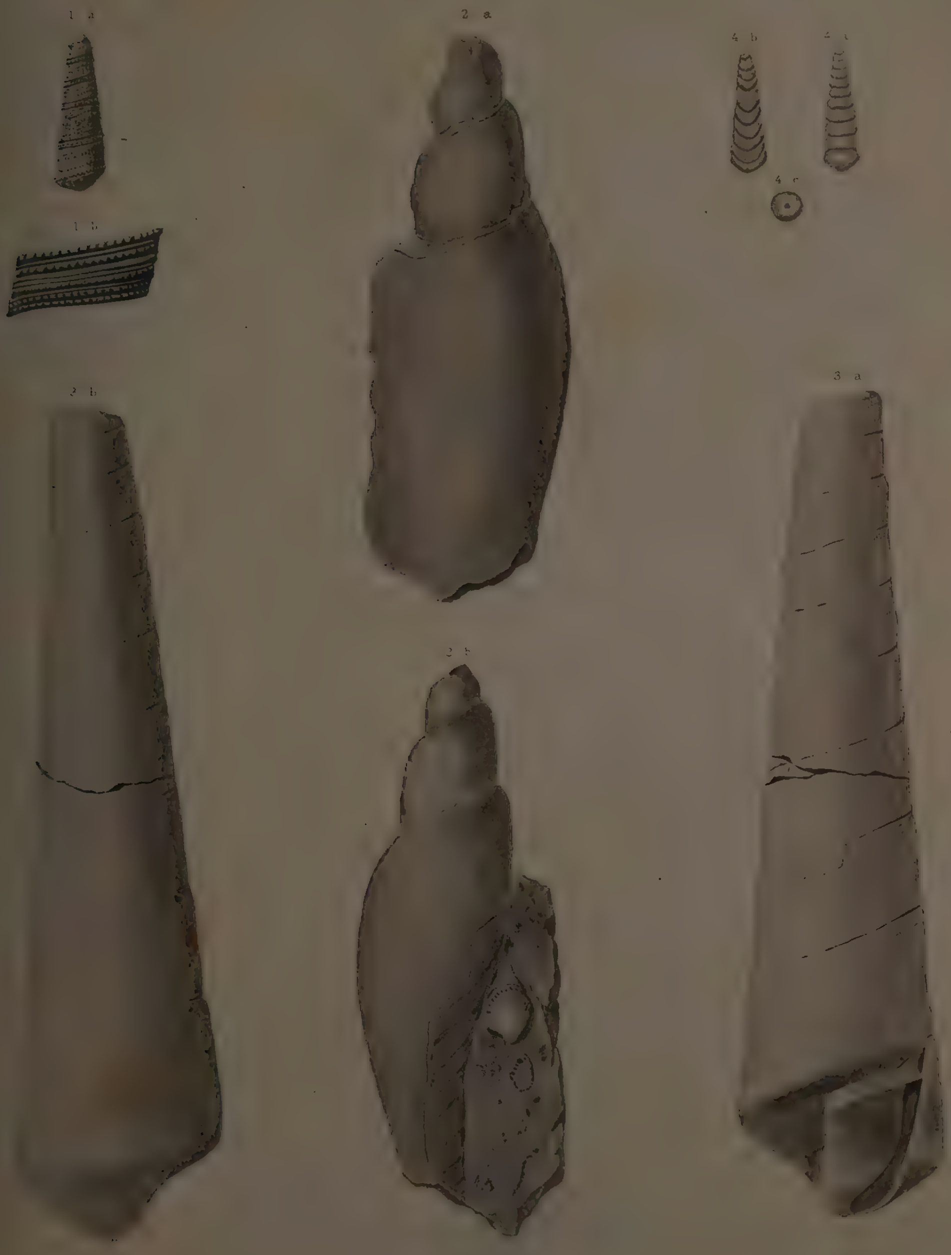


ek del. J.E Gavit sc

1 OSTREA MULTILIRATA

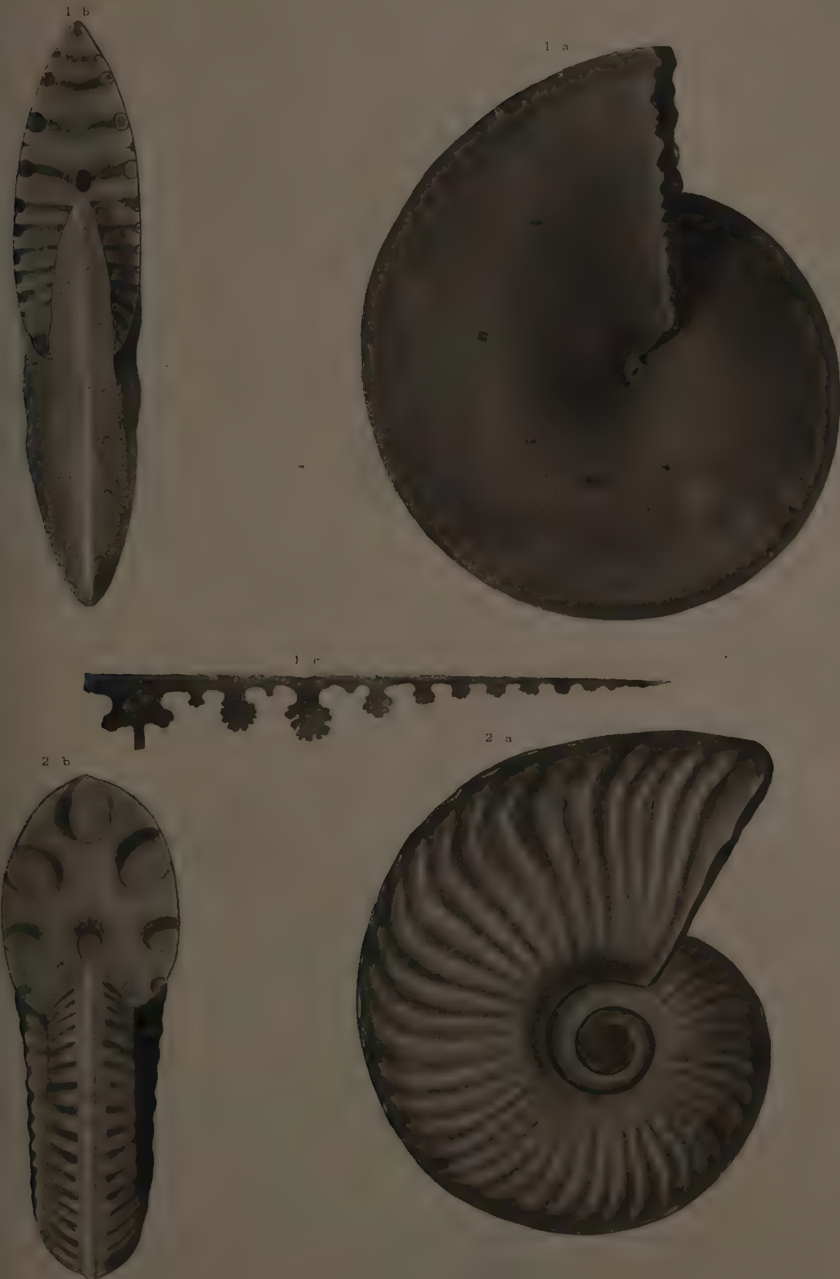
F B Meek del J.E. Gavit sc

1 NATICA TEXANA. 2 NATICA COLLINA. 3 ROSTELLARIA ? COLLINA. 4 ROSTELLARIA ? TEXANA. 5 BUCCINOPSIS PARRYI.



J. E. Gavit sc.

1 TURRITELLA PLANILATERIS 2 ROSTELLITES TEXANA 3 NERINEA SCHOTTII 4 NODOSARIA TEXANA



Meek del.

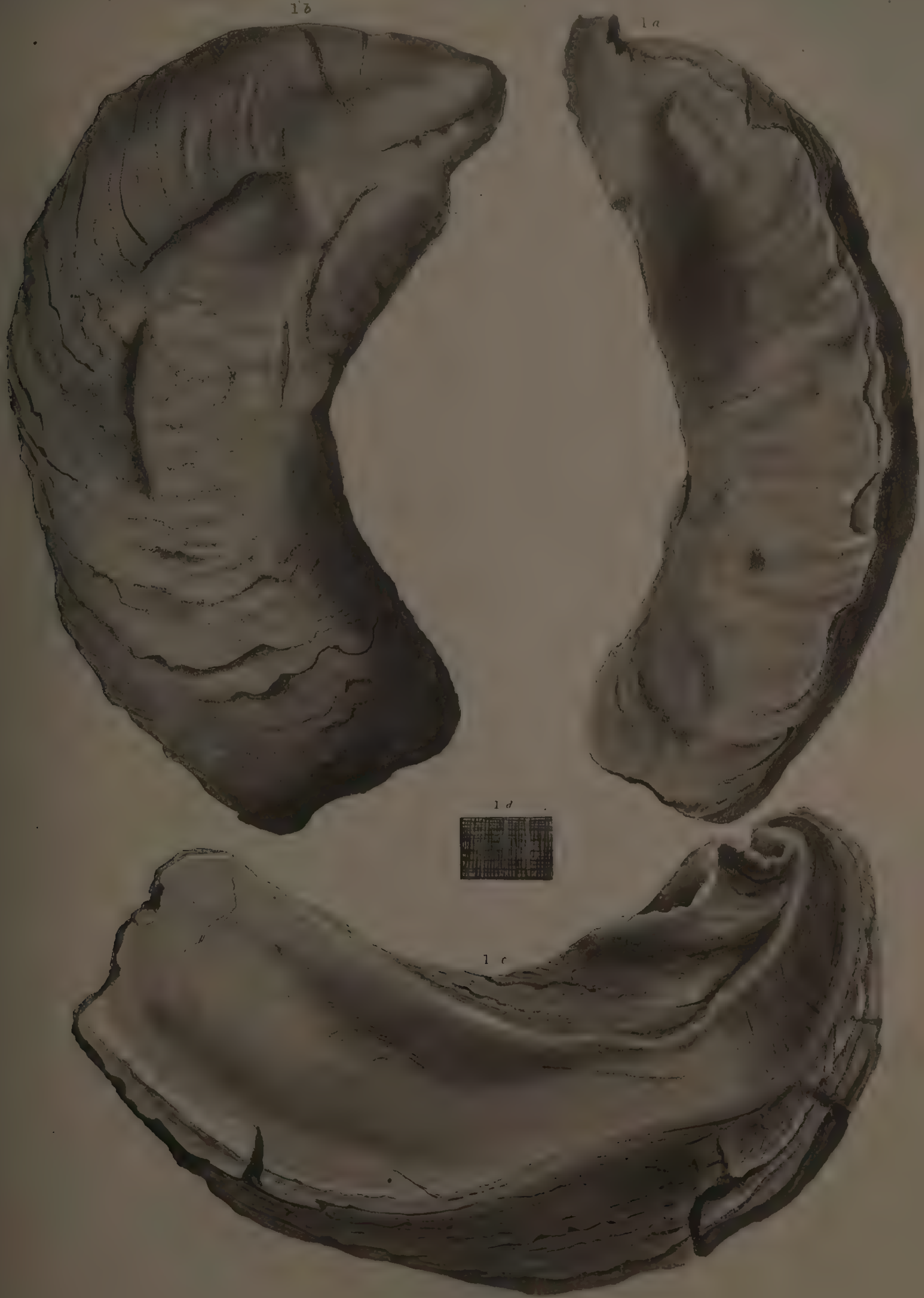
J. E. Gavit sc.

1 AMMONITES PEDERNALIS, VAR. 2 AMMONITES GENICULATUS

1 AMMONITES TEXANUS. 2 A. LEONENSIS.

F. B. Meek Del. W. H. Dougal Sc.

1 OSTREA VESPERTINA. 2 O. VELENIANA

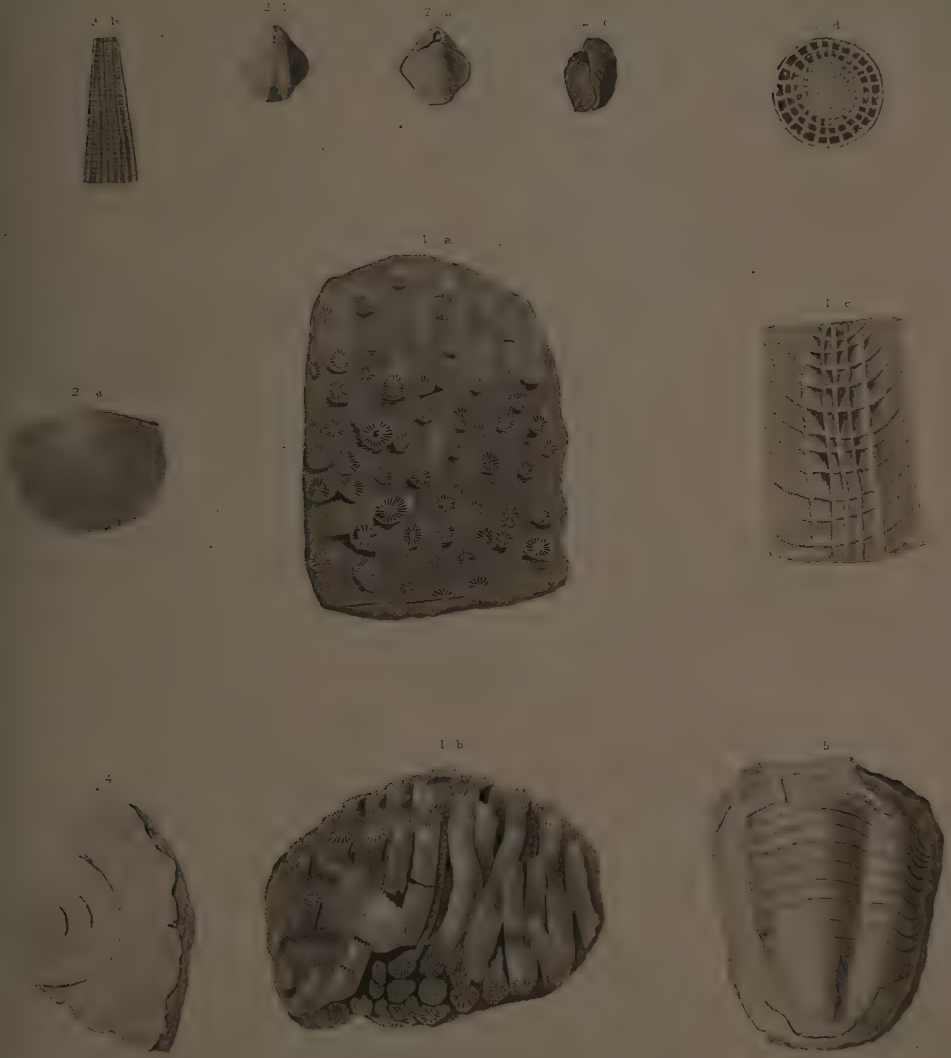


F. B. Meek del. J. E. Gavit sc

1. OSTREA CONTRACTA

F. B. Meek Del. W. H. Dougal Sc.

1 ANOMIA SUBCOSTATA. 2 CARDITA PLANICOSTA. 3 PHOLADOMYA TEXANA. (Cretaceous) 4 CORBULA NASUTA. 5 VENUS VESPERTINA.
6 VOLUTILITHES SAYANA. 7 NATICA EMINULA. 8 TURRITELLA. 9 CASSIDULA (LACINIA) ALVEATA.



F. B. Meek del. J. E. Gavit sc.

1 COLUMNARIA THOMII. 2 TEREBRATULA MEXICANA. 3 ORTHIS ARACHNOIDES. 4 EUOMPHALUS MICHLERANUS. 5 ASAPHUS EMORYI.

F B Meek Del W. H Dougal Sc

1 HOLASTER ELEGANS. 2 TEREBRATULA LEONENSIS. 3 GRYPHÆA PITCHERI. 4 PHOLADOMYA SANCTI-SABIÆ. 5 CARDITA SUBTETRICA
6 CAPSA TEXANA. 7 TURRITELLA LEONENSIS. 8 HAMITES LARVATUS.


MAP
Illustrating the General Geological features
OF THE COUNTRY
WEST OF THE MISSISSIPPI RIVER.
Compiled from the surveys of W. H. Emory and
from the Pacific Railroad Surveys & other sources.
BY
Professor JAMES HALL,
ASSISTED BY
J. P. Lesley, Esq.
BRITISH POSSESSIONS
PACIFIC OCEAN
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
KANSAS
TEXAS
NEW MEXICO
UTAH
LOWER CALIFORNIA
Desert Quaternary
Tertiary
Upper & Cretaceous
Middle Nº 2 3 4 5
Lower Cretaceous Nº 1
Upper Carboniferous Limestone
Coal Measures
Lower Carboniferous Limestone
Devonian
Upper Silurian
Lower Silurian
Metamorphic
Lava & other igneous Rocks
Lith. of Sarony Major & Knapp 449 Broadway New York